



**Rules and
Regulations for
the Classification
of Ships, July 2011**

Notice No. 9

Effective Date of Latest
Amendments:

See page 1

Issue date: May 2012

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RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS, *July 2011*

Notice No. 9

This Notice contains amendments within the following Sections of the *Rules and Regulations for the Classification of Ships, July 2011*. The amendments are effective on the dates shown:

Part	Chapter	Section	Effective date
1	2	2	1 July 2012
3	2	1	1 July 2012
5	1	3	1 July 2012
5	2	Whole Section	1 July 2012
5	3	4 & 6	1 July 2012
5	4	8	1 July 2012
5	5	3, 6	1 July 2012
5	6	3	1 July 2012
5	7	5	1 July 2012
5	10	15	1 July 2012
5	11	1	1 July 2012
5	12	1, 2, 8, 9	1 July 2012
5	13	5 & 6	1 July 2012
5	14	8, 9, 12	1 July 2012
5	15	1	1 July 2012
5	18	3	1 July 2012
6	1	1, 2, 3, 4	1 July 2012
6	2	Whole Section	1 July 2012
7	9	1, 2, 3, 5	1 July 2012
7	13	1	1 July 2012
7	16	2	1 July 2012

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules and Regulations for the Classification of Ships, July 2011* are to be read in conjunction with this Notice No. 9. The status of the Rules is now:

Rules for Ships	Effective date:	1 July 2011
Notice No. 1	Effective date:	1 July 2011
Notice No. 2	Effective date:	1 January 2012 & Corrigendum
Notice No. 3	Effective date:	1 January 2012
Notice No. 4	Effective date:	1 January 2012
Notice No. 5	Effective date:	1 July 2012
Notice No. 6	Effective date:	1 July 2012
Notice No. 7	Effective date:	1 July 2012 & Corrigendum
Notice No. 8	Effective date:	Corrigenda
Notice No. 9	Effective date:	1 July 2012

Part 1, Chapter 2

Classification Regulations

Effective date 1 July, 2012

Section 2

Character of classification and class notations

2.4 Class notations (machinery)

2.4.1 The following class notations are associated with the machinery construction and arrangement, and may be assigned as considered appropriate by the Classification Committee, see *also* Table 2.2.4:

LMC This notation will be assigned when the propelling and essential auxiliary machinery, *see* 2.8.1, have been constructed, installed and tested under LR's Special Survey and in accordance with LR's Rules and Regulations for the Classification of Ships, *see* 3.2.

[LMC] This notation will be assigned when the propelling arrangements, steering systems, pressure vessels and the electrical equipment for essential systems have been constructed, installed and tested under LR's Special Survey and are in accordance with LR's Rules and Regulations. Other items of machinery for propulsion and electrical power generation including propulsion gearing arrangements and other auxiliary machinery for essential services that are in compliance with LR Rules and supplied with the manufacturer's certificate will be acceptable under this notation. The system arrangements of propelling and essential auxiliary machinery are required to be appraised by LR, and found to be acceptable to LR. *See* Section 2.8.2 below.

- the propelling arrangements for propellers, propulsion shafting and multiple input/output gearboxes, steering systems, pressure vessels and electrical equipment for essential systems have been constructed, installed and tested under LR's Special Survey and are in accordance with LR's Rules and Regulations, *see* 3.2.
- other items of machinery and gearing arrangements for propulsion and electrical power generation and other auxiliary machinery for essential services are in compliance with LR Rules and supplied with the Manufacturer's certificate, *see* 2.8.2.
- the system arrangements of propelling and essential auxiliary machinery, *see* 2.8.1, are appraised and found to be acceptable to LR.

LMC

This notation will be assigned when the propelling and essential auxiliary machinery have neither been constructed nor installed under LR's Special Survey but the existing machinery, its installation and arrangement, have been tested and found to be acceptable to LR. This notation is assigned to existing ships in service accepted or transferring into LR class, to existing ships in service that will be accepted or transferred into LR class when:

- the propelling and essential auxiliary machinery, *see* 2.8.1, have neither been constructed nor installed under LR's Special Survey.
- the existing machinery installation and arrangement have been tested and found to be acceptable to LR.

MCH

This notation will be assigned when the propelling and essential auxiliary machinery has been installed and tested under LR's survey requirements and found to be acceptable to LR. Items of machinery and equipment for propelling and auxiliary machinery for essential services supplied with the manufacturer's certificate will be acceptable under this class notation. The system arrangements of propelling and essential auxiliary machinery are required to be appraised by LR, and found to be acceptable to LR. *See* Section 2.8.3 below.

- propelling and essential auxiliary machinery, *see* 2.8.1, has been installed and tested under LR's survey and found to be acceptable to LR.
- propelling and essential auxiliary machinery has been supplied with a Manufacturer's certificate, *see* 2.8.3.
- system arrangements of propelling and essential auxiliary machinery, *see* 2.8.1, are appraised and found to be acceptable to LR.

IGS

This notation will be assigned when a ship intended for the carriage of oil in bulk, or for the carriage of liquid chemicals in bulk, is fitted with an approved system for producing gas for inerting the cargo tanks.

PMR

This notation will be assigned where the main propulsion systems are arranged such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

PMR* This notation will be assigned where the main propulsion systems are arranged such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and where the machinery is installed in separate compartments such that, in the event of the loss of one compartment, the ship will retain availability of propulsion power. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

SMR This notation will be assigned where the steering systems for manoeuvring are arranged so that steering capability will continue to be available in the event of a single failure in the steering gear equipment or loss of power supply or control system for any steering system. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

SMR* This notation will be assigned where the steering systems for manoeuvring are arranged so that steering capability will continue to be available in the event of a single failure in the steering gear equipment or loss of power supply or control system for any steering system and where the steering systems are installed in separate compartments such that, in the event of the loss of one compartment, steering capability will continue to be available. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

PSMR This notation will be assigned where the main propulsion and steering systems are configured such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and retain steering capability. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

PSMR* This notation will be assigned where the main propulsion and steering systems are configured such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and retain steering capability. The propulsion and steering arrangements are to be installed in separate compartments such that in the event of the loss of one compartment, the ship will retain availability of propulsion power and manoeuvring capability. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

(Part only shown)

2.4.2 The following class notations are associated with the machinery control and automation, and may be assigned as considered appropriate by the Classification Committee:

PORT Assigned when equipment is installed for the automation of in-port operations involving manoeuvring, berthing and laying alongside. For the assignment of this notation, the ship is also to be assigned **UMS**.

(Part only shown)

2.4.3 The following class notations are associated with dynamic positioning arrangements, and may be assigned as considered appropriate by the Classification Committee:

PCR() This rating supplements the **DP()** notation. This rating indicates the calculated percentage of time that a unit is capable of holding heading and position under a standard set of environmental conditions (North Sea).

Two rating numerals are calculated:

- The first numeral represents the percentage of time that the ship can remain on station when subjected to a set of standard environmental conditions (North Sea fully developed) with all thrusters operating.
- The second numeral represents the percentage of time that the ship can remain on station when subjected to a set of standard environmental conditions (North Sea fully developed) with the most effective thruster being inoperative.
- A typical rating might be (95),(70).

2.4.5 The following class notation is associated with on-shore power supply arrangements and may be assigned as considered appropriate by the Classification Committee, on application from the Owners:

OPS This notation will be assigned when machinery, electrical and control engineering arrangements installed onboard to permit continued operation of services by connection to an external electrical power supply are assessed and found to comply with the relevant requirements of the Rules.

2.4.6 2.4.5 Machinery class notations will not be assigned to ships the hulls of which are not classed or intended to be classed with LR.

2.4.7 2.4.6 The notations **⊠ LMC**, **⊠ LMC**, **[⊠] LMC**, **⊠ LMC (without ⊠)** and **MCH** will in general not be assigned to non-propelled craft, but individual cases will be considered on their merits.

Part 1, Chapter 2

Table 2.2.4 Machinery Class Notations

Machinery Notations See 2.4, 2.5, 2.6		
⌘ LMC Propulsion and essential machinery [⌘] LMC Propulsion and essential machinery ⌘ LMC Propulsion and essential machinery MCH Propulsion and essential machinery IGS Inert Gas System UMS Unattended Machinery Spaces CCS Centralised Control Station ICC Integrated Computer Control IP Integrated Propulsion IFP Integrated Fire Protection PORT Automation of in-port operation only assigned to addition to UMS DP(CM) Dynamic Position (Centralised Remote Manual Controls) DP(AM) Dynamic Position (Automatic main and Manual standby Controls) DP(AA) Dynamic Position (Automatic main and Automatic standby Controls) DP(AAA) Dynamic Positioning (Automatic main and Automatic standby controls with additional/emergency Automatic control) PCR() Performance Capability Rating NAV1 Navigation Equipment IBS Integrated Bridge System	OPS Operation of Services by connection to an external electrical Power Supply PM Positional Mooring System PMC Positional Mooring System for mooring in Close proximity to other vessels or installations GF Natural Gas Fuelled Ships PMR Propulsion System Redundancy PSMR Propulsion and Steering System Redundancy PSMR* Propulsion and Steering System Redundancy in Separate Compartments PMRL Propulsion System Redundancy with Limited Capacity PMRL* Propulsion System Redundancy in Separate Compartments with Limited Capacity SMRL Steering System Redundancy with Limited Capacity SMRL* Steering System Redundancy in Separate Compartments with Limited Capacity PSMRL Propulsion and Steering System Redundancy with Limited Capacity PSMRL* Propulsion and Steering System Redundancy in Separate Compartments with Limited Capacity CAC1(1 or 2 or 3) Crew Accommodation Comfort PAC1 (or 2 or 3) Passenger Accommodation Comfort PCAC1 (or 2 or 3), 1 (or 2 or 3) Passenger and Crew Accommodation	⌘ Lloyd's RMC Refrigerated Machinery Lloyd's RMC Refrigerated Machinery ‡ Double Dagger – Suitable for carriage of fruit ⌘Lloyd's RMC (LG) Reliquefaction and/or refrigeration equipment is fitted Lloyd's RMC (LG) Reliquefaction and/or refrigeration equipment is fitted ⌘Lloyd's RMC (BC) Refrigerated Chemical tanker Lloyd's RMC (BC) Refrigerated Chemical Tanker TC Chemical Tanker temperature Control Systems (CA) Controlled Atmosphere CA (%O₂, %CO₂) Controlled Atmosphere RH Relative Humidity

2.5 Class notations (machinery special features)

2.5.1 The following class notation is associated with onshore power supply arrangements and may be assigned as considered appropriate by the Classification Committee, upon application from the Owners:

OPS Assigned when the machinery, electrical and control engineering arrangements installed on board to permit continued operation of services by connection to an external electrical power supply have been assessed.

2.5.2 The following class notations are associated with positional mooring systems, or thruster-assisted positional mooring systems, and may be assigned as considered appropriate by the Classification Committee:

PM Assigned when a positional mooring system is fitted. It is not intended to apply to vessels which have station-keeping capabilities, but which are not required to remain on station in adverse weather conditions. This notation can be supplemented by a Thrust-Assisted notation **T1** [or **T2** or **T3**].

PMC Assigned when a positional mooring system for mooring in close proximity to other vessels or installations is fitted. It is not intended to apply to vessels which have station-keeping capabilities, but which are not required to remain on station in adverse weather conditions. This notation can be supplemented by a Thrust-Assisted notation **T1** [or **T2** or **T3**].

GF Assigned to ships other than LNG carriers, where the main propelling and/or auxiliary machinery is designed to operate on natural gas as fuel, or a combination of natural gas and oil fuel. The notation also indicates that the gas-fuelled machinery has been installed and tested in accordance with LR's Rules and Regulations.

2.5.3 The following class notations are associated with machinery redundancy and may be assigned as considered appropriate by the Classification Committee:

PMR This notation will be assigned where the main propulsion systems are arranged such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems. It also denotes that the installation has been arranged, installed and tested in accordance with LR Rules.

PMR* This notation will be assigned where the main propulsion systems are arranged such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and where the machinery is installed in separate compartments such that, in the event of the loss of one compartment, the ship will retain availability of propulsion power. It also denotes that the

installation has been arranged, installed and tested in accordance with LR Rules.

SMR This notation will be assigned where the steering systems for manoeuvring are arranged so that steering capability will continue to be available in the event of a single failure in the steering gear equipment or loss of power supply or control system for any steering system. It also denotes that the installation has been arranged, installed and tested in accordance with LR's Rules.

SMR* This notation will be assigned where the steering systems for manoeuvring are arranged so that steering capability will continue to be available in the event of a single failure in the steering gear equipment or loss of power supply or control system for any steering system and where the steering systems are installed in separate compartments such that, in the event of the loss of one compartment, steering capability will continue to be available. It also denotes that the installation has been arranged, installed and tested in accordance with LR's Rules.

PSMR This notation will be assigned where the main propulsion and steering systems are configured such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and retain steering capability. It also denotes that the installation has been arranged, installed and tested in accordance with LR's Rules.

PSMR* This notation will be assigned where the main propulsion and steering systems are configured such that, in the event of a single failure in equipment, the ship will retain not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and retain steering capability. The propulsion and steering arrangements are to be installed in separate compartments such that, in the event of the loss of one compartment, the ship will retain availability of propulsion power and manoeuvring capability. It also denotes that the installation has been arranged, installed and tested in accordance with LR's Rules.

The foregoing machinery redundancy notations may be supplemented with the additional **L** character which indicates a limited capability.

Part 1, Chapter 2

2.5.4 The following class notations are associated with comfort control and may be assigned as considered appropriate by the Classification Committee:

CAC1	(or 2 or 3) Assigned when noise and vibration levels in crew accommodation and work areas have been assessed. Numerals 1 or 2 or 3 indicate the acceptance criterion to which the noise and vibration levels have been assessed. Primarily intended to apply to passenger ships. If requested, however, any ship can be assessed for compliance.
PAC1	(or 2 or 3) Assigned when noise and vibration levels in passenger accommodation have been assessed. Numerals 1 or 2 or 3 indicate the acceptance criterion to which the noise and vibration levels have been assessed. Primarily intended to apply to passenger ships. If requested, however, any ship can be assessed for compliance.
PCAC1	(or 2 or 3), (1 or 2 or 3) Assigned when noise and vibration levels in passenger and crew spaces have been assessed. Numerals 1 or 2 or 3 indicate the acceptance criterion to which the noise and vibration levels have been assessed. Two numerals will be assigned, the first for the acceptance criteria for passenger accommodation, the second for crew comfort criteria. Primarily intended to apply to passenger ships. If requested, however, any ship can be assessed for compliance.

Existing sub-Section 2.6 has been deleted.

2.5 2.6 Class notations (refrigerated cargo installations (RMC), controlled atmosphere (CA) systems and carriage of refrigerated containers (CRC))

(Part only shown)

~~2.5.4~~ **2.6.1** The following class notations may be assigned as considered appropriate by the Classification Committee, on application from the Owners:

Lloyd's RMC (LG) This notation will be assigned to a classed liquefied gas carrier or tanker, in which reliquefaction or refrigeration equipment is fitted for cargo temperature and pressure control, where the equipment has been found equivalent to Rule requirements and tested in accordance with the relevant requirements of the Rules.

Lloyd's RMC (BC) Assigned to a classed chemical tanker in which refrigeration equipment has been constructed, installed and tested, in accordance with the relevant requirements of the Rules.

Lloyd's RMC (BC) Assigned to a classed chemical tanker where the equipment has been found equivalent to Rule requirements and tested in accordance with the relevant requirements of the Rules.

TC Assigned to a classed chemical tanker where the temperature control systems have been found equivalent to Rule requirements and tested in accordance with the relevant requirements of the Rules.

~~2.5.2~~ **2.6.2** The following class notations are associated with controlled atmospheres and may be assigned as considered appropriate by the Classification Committee, on application from Owners, see also Pt 7, Ch 1:

RH This notation may be assigned when a ship can maintain a specified relative humidity in the CA zones.

RPA Assigned to ships where the Refrigeration Machinery for Provision Stores and Air-conditioning comply with the applicable requirements of Pt 7, Ch 16.

2.8 Application notes

2.8.3 Manufacturer's certificate for assignment of the **MCH** notation. Acceptance of the manufacturer's certificate for propelling and essential auxiliary machinery is subject to the following:

- The ship is a cargo ship of less than 500 gross tonnage or is a ship of 500 gross tonnage or greater and is not required to comply with the international conventions applicable to a ship with unrestricted service.
- Propulsion power is provided by oil engines or gas turbines which have been type approved in accordance with LR requirements for marine application.
- Electrical power is provided by generators driven by oil engines or gas turbines which have been type approved in accordance with LR requirements for marine application.
- The power of any ~~engine or gas turbine~~ prime mover is less than 2,250 kW and the cylinder bore or any diesel engine is not greater than 300 mm.
- The design and manufacture standards for machinery and associated systems are the applicable LR Rules or other marine standards acceptable to LR.
- The machinery and equipment is manufactured under a recognised quality control system in accordance with the requirements of LR's *Rules for the Manufacture, Testing, and Certification of Materials*.
- Individual components manufactured under (f) are to be delivered with a manufacturer's statement confirming that the scantlings comply with the applicable LR Rule requirements.

Part 3, Chapter 2

Materials

Effective date 1 July, 2012

Existing Table 2.1.2 has been deleted.

■ Section 1

Materials of construction

1.3 Aluminium

1.3.5 A comparison of the mechanical properties for selected welded and unwelded alloys is given in ~~Table 2.1.2~~ Ch 13,8.3.2 of the Rules for Materials.

Part 5, Chapter 1

General Requirements for the Design and Construction of Machinery

Effective date 1 July, 2012

■ Section 3

Operating conditions

3.1 Availability for operation

3.1.3 Machinery is to be capable of operating satisfactorily in accordance with the manufacturer's stated operating conditions within an operational profile specified for the ship by the Owner/Operator and agreed by the manufacturer/system designer.

Part 5, Chapter 2

Oil Engines

Effective date 1 July, 2012

■ Section 1

Plans and particulars

1.1 Plans

(Part only shown)

1.1.1 The following plans and particulars as applicable are to be submitted for consideration:

- Schematic layouts showing details and arrangements of oil mist detection/monitoring and alarm systems.
- Diesel generator test results that state the engine maximum load steps which satisfy the quality of power supply requirements specified in Pt 6, Ch 2,1.7.
- Planned operating profiles for the vessel at sea and during manoeuvring as agreed with the operators.

1.1.6 Where engines incorporate electronic control systems the following additional information is to be submitted:

- (a) A general overview of the operating principles, supported by schematics explaining the functionality of individual systems and sub-systems. The information is to relate to the engine capability and functionality under defined operating and emergency conditions such as recovery from a failure or malfunction, with particular reference to the functioning of programmable electronic systems and any sub-systems. The information is also to indicate if the engine has different modes of operation, such as to limit exhaust gas emissions and/or to run under an economic fuel consumption mode or any other mode that is electronically controlled.
- (b) Operating manuals which describe the particulars of each system and, together with maintenance instructions, include reference to the functioning of sub-systems.

- (c) A risk-based analysis of the mechanical, pressure containing, electrical, electronic and programmable electronic systems and arrangements that support the operation of the engine. The analysis is to demonstrate that suitable risk mitigation has been achieved in accordance with 15.3.
- (d) Details of hydraulic systems for actuation of subsystems (fuel injection or exhaust), to include details of the design/construction of pipes, pumps, valves, accumulators and the control of valves/pumps. Details of pump drive arrangements are also to be included.
- (e) Quality plan for sourcing, design, installation and testing of all components used in the oil fuel and hydraulic oil systems installed with the engine for engine operation.
- (f) Fatigue analysis for all high pressure oil fuel and hydraulic oil piping arrangements required for engine operation where failure of the pipe or its connection or a component would be the cause of engine unavailability. The analysis is to concentrate on high pressure components and sub-systems and recognise the pressures and fluctuating stresses that the pipe system may be subject to in normal service.
- (g) Evidence of type testing of the engine with the programmable electronic system, or a proposed test plan at the engine builders with the programmable electronic system functioning, to verify the functionality and behaviour under normal operating and fault conditions of the programmable electronic control system.
- (h) Schedule of testing at engine builders, pre-sea trial commissioning and sea trials. The test schedules are to identify all modes of engine operation and the sea trials are to include typical port manoeuvres under the intended engine operating modes. The schedule is to include:
- testing and trials to demonstrate that the engine is capable of operating as described in (a);
 - tests to verify that the response of the complete mechanical, hydraulic, electrical and electronic system is as predicted for the intended operational modes; and
 - testing required to verify the conclusions of the risk-based analysis.
- The scope of these tests is to be agreed with LR.

Existing paragraph 15.2.2 has been renumbered 1.1.7.

1.1.8 Emergency diesel-generator engine plans, information and test schedules, required for design appraisal, are to be in accordance with Pt 6, Ch 1.

~~10.1.4~~ **1.1.9** ~~The~~ For Turbo-chargers, the following plans and particulars are to be submitted for information:

- Cross-sectional plans of the assembled turbo-charger with main dimensions.
- Fully dimensioned plans of the rotor.
- Material particulars with details of welding and surface treatments.
- Turbo-charger operating and test data.
- A selected turbo-charger is to be type tested.
- Manufacturer's burst test assessment.

~~1.1.6~~ **1.1.10** Where considered necessary, Lloyd's Register (hereinafter referred to as 'LR') may require additional documentation to be submitted.

Section 3 Design

3.12 Alternative method for calculation of stress concentration factors

3.12.1 LR will give consideration to crankshaft design using an alternative method given in LR's *ShipRight procedures for alternative method for calculation of stress concentration factors in the web fillet radii of crankshafts by utilising Finite Element*.

Section ~~15~~ 4 Electronically controlled engines

~~15.1~~ **4.1 Scope General**

Existing paragraphs 15.1.1 to 15.1.6 have been renumbered 4.1.1 to 4.1.6.

Existing sub-Section 15.2 has been deleted.

~~15.3~~ **4.2 Risk-based analysis**

Existing paragraphs 15.3.1 to 15.3.6 have been renumbered 4.2.1 to 4.2.6.

Existing sub-Section 15.4 has been deleted.

~~15.5~~ **4.3 Control engineering systems**

Existing paragraphs 15.5.1 and 15.5.2 have been renumbered 4.3.1 and 4.3.2.

~~15.6~~ **4.4 Software**

Existing paragraphs 15.6.1 to 15.6.3 have been renumbered 4.4.1 to 4.4.3.

Section ~~5~~ ~~Safety arrangements on engines~~

~~5.1~~ **Cylinder relief valves**

~~5.1.1~~ Scavenge spaces in open connection with cylinders are to be provided with explosion relief valves.

~~5.2~~ **Main engine governors**

~~5.2.1~~ An efficient governor is to be fitted to each main engine so adjusted that the speed does not exceed that for which the engine is to be classed by more than 15 per cent.

~~5.2.2~~ Oil engines coupled to electrical generators which are the source of power for main electric propulsion motors are to comply with the requirements for auxiliary engines in respect of governors and overspeed protection devices.

5.3 Auxiliary engine governors

~~5.3.1 Auxiliary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within 10 per cent momentary variation and 5 per cent permanent variation when full load is suddenly taken off or, when after having run on no load for at least 15 minutes, load is suddenly applied as follows:~~

- ~~(a) For engines with BMEP less than 8 bar, full load, or~~
- ~~(b) For engines with BMEP greater than 8 bar, $\frac{800}{\text{BMEP}}$ per cent, but not less than one third, of full load, the full load being attained in not more than two additional equal stages as rapidly as possible.~~

~~5.3.2 Emergency engines are to comply with 5.3.1 except that the initial load required by 5.3.1(b) is to be not less than the total connected emergency statutory load, or if their total consumer load is applied in steps, the following requirements are to be met:~~

- ~~(a) the total load is supplied within 45 seconds from power failure on the main switchboard;~~
- ~~(b) the maximum stop load is declared and demonstrated; and~~
- ~~(c) the power distribution system is designed such that the declared maximum stop loading is not exceeded.~~

~~5.3.3 Compliance of time delays and loading sequence with the requirements of 5.3.2 is to be demonstrated at ship's trials.~~

~~5.3.4 For alternating current installations, the permanent speed variation of the machines intended for parallel operation are to be equal within a tolerance of $\pm 0,5$ per cent. Momentary speed variations with load changes in accordance with 5.3.1 are to return to and remain within one per cent of the final steady state speed. This should normally be accomplished within five but in no case more than eight seconds. For quality of power supplies, see Pt 6, Ch 2, 1.7.~~

5.4 Overspeed protective devices

~~5.4.1 Each main engine developing 220kW (300 shp) or over which can be declutched or which drives a controllable (reversible) pitch propeller, also each auxiliary engine developing 220 kW (300 shp) and over for driving an electric generator, is to be fitted with an approved overspeed protective device.~~

~~5.4.2 The overspeed protective device, including its driving mechanism, is to be independent of the governor required by 5.2 or 5.3 and is to be so adjusted that the speed does not exceed that for which the engine and its driven machinery are to be classed by more than 20 per cent for main engines and 15 per cent for auxiliary engines.~~

Section 4 5

Construction and welded structures

Existing sub-Sections 4.1 to 4.5 have been renumbered 5.1 to 5.5.

Section 17 6

General requirements Turning gear

17.1 16.1 Turning-gear General requirements

Existing paragraphs 17.1.1 to 17.1.7 have been renumbered 6.1.1 to 6.1.7.

Existing sub-Section 7.1 title has been deleted.

7.1 Oil fuel systems

Existing sub-Section 7.2 title has been deleted.

7.2 High pressure oil systems

Section 7

Control and monitoring of main, auxiliary and emergency diesel engines

7.1 General

7.1.1 Control engineering systems are to be in accordance with the requirements of Pt 6, Ch 1.

7.1.2 Oil mist detection, or engine bearing temperature monitors or alternative methods for crankcase protection are to be provided:

- (a) When arrangements are fitted to override the automatic shut-down for excessive reduction of the lubricating oil supply pressure.
- (b) For engines of 2250 kW and above or having cylinders of more than 300 mm bore.

NOTES

1. For medium and high speed engines, automatic shut-down of the engine is to occur.
2. For slow speed engines, automatic slow-down is to occur.
3. Where arrangements are made to override the automatic slow-down or shut-down due to high oil mist or bearing temperature, the override is to be independent of other overrides.
4. Where the bearing temperature monitoring method is chosen, all bearings in the crankcase are to be monitored where practicable, e.g., main, crankpin, crosshead.

5. Where engine bearing temperature monitors or alternative methods are provided for the prevention of the build-up of oil mist that may lead to a potentially explosive condition within the crankcase, details are to be submitted for consideration. The submission is to demonstrate that the arrangements are equivalent to those provided by oil mist detection, see 6.8.14.

7.1.3 All main and auxiliary engines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines are of more than 37 kW (50 shp), audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

7.2 Main engine governors

7.2.1 An efficient governor is to be fitted to each main engine so adjusted that the speed does not exceed that for which the engine is to be classed by more than 15 per cent.

7.2.2 Oil engines coupled to electrical generators which are the source of power for main electric propulsion motors are to comply with the requirements for auxiliary engines in respect of governors and overspeed protection devices.

7.3 Auxiliary engine governors

7.3.1 Auxiliary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within 10 per cent momentary variation and 5 per cent permanent variation when the full load is suddenly taken off or, when after having run on no-load for at least 15 minutes, the load is suddenly applied as follows:

- (a) For engines with BMEP less than 8 bar, full load, or
- (b) For engines with BMEP greater than 8 bar, $\frac{800}{\text{BMEP}}$ per cent, but not less than one third, of full load, the full load being attained in not more than two additional equal stages as rapidly as possible.

7.3.2 If an engine cannot achieve the requirements of 7.3.1 then the actual load step is to be declared and verified through testing to ensure the requirements specified in Pt 6, Ch 2, 1.7 are satisfied.

7.3.3 Emergency engines are to comply with 7.3.1 except that the initial load required by 7.3.1(b) is to be not less than the total connected emergency statutory load, or if their total consumer load is applied in steps, the following requirements are to be met:

- (a) the total load is supplied within 45 seconds from power failure on the main switchboard;
- (b) the maximum step load is declared and demonstrated; and
- (c) the power distribution system is designed such that the declared maximum step loading is not exceeded.

7.3.4 Compliance of time delays and loading sequence with the requirements of 7.3.2 is to be demonstrated at the ship's trials.

7.3.5 For alternating current installations, the permanent speed variation of the machines intended for parallel operation are to be equal within a tolerance of $\pm 0,5$ per cent. Momentary speed variations with load changes in accordance with 7.3.1 are to return to and remain within one per cent of the final steady state speed. This should normally be accomplished within five but in no case more than eight seconds. For quality of power supplies, see Pt 6, Ch 2, 1.7.

7.4 Overspeed protective devices

7.4.1 Each main engine developing 220kW (300 shp) or over which can be declutched or which drives a controllable pitch propeller, and also each auxiliary engine developing 220 kW (300 shp) and over for driving an electric generator, is to be fitted with an approved overspeed protective device.

7.4.2 The overspeed protective device, including its driving mechanism, is to be independent of the governor required by 7.2 or 7.3 and is to be so adjusted that the speed does not exceed that for which the engine and its driven machinery are to be classed by more than 20 per cent for main engines and 15 per cent for auxiliary engines.

7.5 Unattended machinery

7.5.1 Where main and auxiliary diesel engines are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms and safety arrangements required by 7.5 to 7.7, as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

7.5.2 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start-up under conditions which could hazard the machinery.

7.5.3 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

7.5.4 Where a first stage alarm together with a second stage alarm and automatic shut-down of machinery are required in the relevant Tables of this Section, the sensors and circuits utilised for the second stage alarm and automatic shut-down are to be independent of those required for the first stage alarm.

7.5.5 Means are to be provided to prevent leaks from high pressure oil fuel injection piping for main and auxiliary engines dripping or spraying onto hot surfaces or into machinery air inlets. Such leakage is to be collected and, where practicable, led to a collector tank(s) fitted in a safe position. An alarm is to be provided to indicate that leakage is taking place. These requirements may also be applicable to high pressure hydraulic oil piping, depending upon the location.

7.6 Oil engines for propulsion purposes

7.6.1 Alarms and safeguards are indicated in 7.6.2 to 7.6.8 and Tables 2.7.1(a) and (b).

7.6.2 Alarms are to operate for the fault conditions shown in Table 2.7.1(a). Where applicable, indication is to be given at the relevant control stations that the speed or power of the main propulsion engine(s) is to be manually reduced or has been reduced automatically.

7.6.3 Alarms are to operate, and automatic shut-down of machinery is to occur for the fault conditions shown in Table 2.7.1(b).

7.6.4 The following engine services are to be fitted with automatic temperature controls so as to maintain steady state conditions throughout the normal operating range of the propulsion engine(s).

- (a) Lubricating oil supply.
- (b) Oil fuel supply, *see also* 7.6.5.
- (c) Piston coolant supply, where applicable.
- (d) Cylinder coolant supply, where applicable.
- (e) Fuel valve coolant supply, where applicable.

7.6.5 The oil fuel supply may be fitted with an automatic control for viscosity instead of the temperature control required by 7.6.4.

7.6.6 Indication of the starting air pressure is to be provided at each control station from which it is possible to start the main propulsion engine(s).

7.6.7 The number of automatic consecutive attempts which fail to produce a start is to be limited to three. For reversible engines which are started and stopped for manoeuvring purposes, means are to be provided to maintain sufficient starting air in the air receivers. For electric starting, *see* 8.4.

7.6.8 Prolonged running in a restricted speed range is to be prevented automatically or, alternatively, an indication of restricted speed ranges is to be provided at each control station.

7.7 Auxiliary engines

7.7.1 Alarms and safeguards are indicated in Table 2.7.2.

7.7.2 For engines operating on heavy oil fuel, automatic temperature or viscosity controls are to be provided.

7.8 Emergency diesel engines

7.8.1 Alarms and safeguards are to be fitted in accordance with Table 2.7.3.

7.8.2 The safety and alarm systems are to be designed to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the ship.

7.8.3 Regardless of the engine output power, if shut-downs additional to those specified in Table 2.7.3 are provided except for the overspeed shut-down, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

7.8.4 Grouped alarms of at least those items listed in Table 2.7.3 are to be arranged on the bridge.

7.8.5 In addition to the fuel oil control from outside the space, a local means of engine shut-down is to be provided.

7.8.6 Local indications of at least those items listed in Table 2.7.3 are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

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Table 2.7.1(a) Oil engines for propulsion purposes: Alarms and slow-downs (see continuation)

Item	Alarm	Note
Lubricating oil sump level	Low	Engines
Lubricating oil inlet pressure*	1st stage low	Engines. Slow-down
Lubricating oil inlet temperature*	High	Engines
Lubricating oil filters differential pressure	High	—
Oil mist concentration in crankcase or bearing temperature	High	Automatic slow-down of slow speed engines, see 7.1.2. One sensor per lubricator unit. Slow-down (automatic on medium and high speed engines)
Cylinder lubricator flow	Low	
Thrust bearing temperature*	High	Slow-down
Common rail servo oil pressure	Low	—
Piston coolant inlet pressure	Low	If a separate system. Slow-down
Piston coolant outlet temperature*	High	Per cylinder (if a separate system). Slow-down
Piston coolant outlet flow*	Low	Per cylinder (if a separate system)
Cylinder coolant inlet pressure or flow*	Low	Slow-down (automatic on medium and high speed engines)
Cylinder coolant outlet temperature*	1st stage high	Per cylinder (if a separate system). Slow-down (automatic on medium and high speed engines)
Engine cooling water system – oil content	High	Where engine cooling water used in oil/water heat exchangers
Sea-water cooling pressure	Low	—
Fuel valve coolant pressure	Low	If a separate system
Fuel valve coolant temperature	High	If a separate system
Oil fuel pressure from booster pump	Low	—
Oil fuel temperature or viscosity*	High and Low	Heavy oil only
Oil fuel high pressure piping*	Leakage	See 7.5.5
Common rail fuel oil pressure	Low	—
Charge air cooler outlet temperature	High and Low	4-stroke medium and high speed engines
Scavenge air temperature (fire)	High	Per cylinder (2-stroke engines). Slow-down
Scavenge air receiver water level	High	—

Table 2.7.1(a) Oil engines for propulsion purposes: Alarms and slow-downs (*conclusion*)

Item	Alarm	Note
Exhaust gas temperature*	High	Per cylinder. Slow-down (automatic on medium and high speed engines), see Note 5
Exhaust gas temperature deviation from average*	High	Per cylinder, see Note 5
Turbo-charger exhaust gas inlet temperature	High	Each turbo-charger See Note 6
Turbo-charger exhaust gas outlet temperature*	High	Each turbo-charger
Turbo-charger lubricating oil inlet pressure	Low	If system not integral with turbo-charger
Turbo-charger lubricating oil outlet temperature	High	Each bearing, if system not integral with turbo-charger. See Note 7
Starting air pressure*	Low	Before engine manoeuvring valve
Control air pressure	Low	—
Direction of rotation	Wrong way	Reversible engines, see also 9.6.7
Automatic start of engine	Failure	See 7.6.7
Electrical starting battery charge level	Low	—
Feed water or water/thermal fluid forced circulation flow (if fitted)	Low	See Ch 14,6.2.7 and Note 8
Uptake temperature	High	To monitor for soot fires. See Notes 8 and 9
NOTES - Where 'per cylinder' appears in this Table, suitable sensors may be situated on manifold outlets for medium and high speed engines. - For engines and gearing of 1500 kW or less, only the items marked* are required. - Common sensors are acceptable for alarms and slow-down functions. - Except where stated otherwise in the Table, slow-down may be effected by either manual or automatic means, by reduction of speed or power as appropriate. - For medium and high speed engine power <500 kW/cylinder, a common sensor for exhaust gas manifold temperature may be fitted. - May be combined with exhaust gas outlet temperature high alarm where the turbo-charger is mounted directly on the exhaust manifold. - Where the outlet temperature for each bearing cannot be measured due to the design, details of alternative proposals in accordance with the turbo-charger manufacturer's instructions may be submitted for consideration. - Alarm only required when an exhaust gas economiser/boiler/thermal oil heater is fitted. - Alternatively, details of an appropriate fire detection system are to be submitted for consideration.		

Table 2.7.1(b) Oil engines for propulsion purposes: Alarms and slow-downs

Item	Alarm	Note
Lubricating oil inlet pressure	2nd stage low	Automatic shut-down of engines, see 7.5.4
Oil mist concentration in crankcase or bearing temperature	High	Automatic shut-down of medium and high speed engines, see 7.1.2
Cylinder coolant outlet temperature	2nd stage high	Automatic shut-down of medium and high speed engines, see 7.5.4
Overspeed	High	Automatic shut-down of engine, see also 7.4. Details of alternative proposals in accordance with the manufacturer's instructions may be submitted for consideration

Part 5, Chapter 2

Table 2.7.2 Auxiliary engines: Alarms and safeguards

Item	Alarm	Note
Lubricating oil inlet temperature	High	—
Lubricating oil inlet pressure	1st stage low	—
	2nd stage low	Automatic shut-down of engine, see 7.5.4
Oil mist concentration in crankcase or bearing temperature	High	Automatic shut-down of engine, see 7.1.2
Oil fuel high pressure piping	Leakage	See 7.5.5
Coolant outlet temperature (for engines >220 kW)	1st stage high	—
	2nd stage high	Automatic shut-down of engine, see 7.5.4
Coolant pressure or flow	Low	—
Oil fuel temperature or viscosity	High and Low	Heavy oil only
Overspeed	High	Automatic shut-down of engine, see also 7.4. Details of alternative proposals in accordance with the manufacturer's instructions may be submitted for consideration
Common rail servo oil pressure	Low	—
Common rail fuel oil pressure	Low	—
Starting air pressure	Low	—
Electrical starting battery charge level	Low	—
Exhaust gas temperature (for engines >500 kW/cylinder)	High	Per cylinder.
Feed water or water/thermal fluid forced circulation flow (if fitted)	Low	See Ch 14,6.2.7 and Note 3
Uptake temperature	High	To monitor for soot fires. See Notes 3 and 4

NOTES

1. For emergency diesel engines, including engines used for the emergency source of electrical power required by SOLAS, see Ch 2,16.
2. The arrangements are to comply with the requirements of the National Authority concerned.
3. Alarm only required when an exhaust gas economiser/boiler/thermal oil heater is fitted.
4. Alternatively, details of an appropriate fire detection system are to be submitted for consideration.

Table 2.7.3 Emergency diesel engines: Alarms and safeguards

Item	Alarm for engine power <220 kW	Alarm for engine power ≤ 220kW	Note
Fuel oil leakage from pressure pipes	Leakage	Leakage	See 7.1.2
Lubricating oil temperature	—	High	—
Lubricating oil pressure	Low	Low	—
Oil mist concentration in crankcase	—	High	See Note
Coolant pressure or flow	—	Low	—
Coolant temperature (can be air)	High	High	—
Overspeed	—	High	Automatic shut-down

NOTE

For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.

Section 7 8

Piping

7.1 Oil fuel systems

15.4 8.1 Oil fuel, and hydraulic and high pressure oil systems

~~15.4.1~~ 8.1.1 Oil fuel and hydraulic oil piping systems arrangements are to comply with Chapters 2, ~~11~~, ~~12~~, ~~15~~ 12 and ~~16~~ 14 as applicable.

~~7.1.3~~ 8.1.2 Oil fuel pipe systems in general, tanks and their fittings are to comply with the requirements of Chapter 14 and Part 3.

~~15.4.2~~ 8.1.3 Where pumps are essential for engine operation, not less than two oil fuel and two hydraulic oil pressure pumps are to be provided for their respective service and arranged such that failure of one pump does not render the other inoperative. Each oil fuel pump and hydraulic oil pump is to be capable of supplying the quantity of oil for engine operation at its maximum continuous rating and arranged ready for immediate use.

~~7.1.1~~ 8.1.4 All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high pressure line failure. If flexible hoses are used for shielding purposes, these arrangements are to be approved.

~~15.4.4~~ 8.1.5 The hydraulic oil pressure piping between the high pressure hydraulic pumps and hydraulic actuators is to be protected with a jacketed piping system capable of containing hydraulic oil leakage from a high pressure pipe failure.

~~7.2.1~~ 8.1.6 Where flammable oils are used in high pressure systems, the oil pipe lines between the high pressure oil pump and actuating oil pistons are to be protected with a jacketed piping system capable of preventing oil spray from a high-pressure line failure.

~~15.4.5~~ 8.1.7 Accumulators and associated high pressure piping are to be designed, manufactured and tested in accordance with a standard applicable to the maximum pressure and temperature rating of the system.

~~7.1.4~~ 8.1.8 Diesel engine fuel system components are to be designed to accommodate the maximum peak pressures experienced in service. In particular this applies to the fuel injection pump supply and spill line piping which may be subject to high-pressure pulses from the pump. Connections on such piping systems should be chosen to minimise the risk of pressurised oil fuel leaks.

~~7.1.2~~ 8.1.9 The protection is to prevent oil fuel or oil fuel mist from reaching a source of ignition on the engine or its surroundings. Suitable drainage arrangements are to be made for draining any oil fuel leakage to collector tank(s) fitted in a safe position. An alarm is to be provided to indicate that leakage is taking place.

~~7.1.5~~ 8.1.10 Where multi-engined installations are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines are to be provided. These means of isolation are not to affect the operation of the other engines and are to be operable from a position not rendered ~~inaccessible~~ ~~inaccessible~~ by a fire on any of the engines.

Existing paragraphs 15.4.6 to 15.4.12 have been renumbered 8.1.11 to 8.1.17.

7.3 8.2 Exhaust systems

Existing paragraphs 7.3.1 to 7.3.5 have been renumbered 8.2.1 to 8.2.5.

7.4 8.3 Starting air pipe systems and safety fittings

Existing paragraphs 7.4.1 to 7.4.7 have been renumbered 8.3.1 to 8.3.7.

Section 8 9

Air compressors and starting arrangements

Starting arrangements

Existing sub-Sections 8.11 to 8.15 have been renumbered 9.1 to 9.5.

Section 6 10

Crane safety fitting

Safety arrangements

Existing paragraphs 10.1 and 10.1.1 have been deleted.

6.1 10.1 Relief valves

10.1.1 Scavenge spaces in open connection with cylinders are to be provided with explosion relief valves.

Existing paragraphs 6.1.1 to 6.1.7 have been renumbered 10.1.2 to 10.1.8.

6.2 10.2 Number of relief valves

Existing paragraphs 6.2.1 to 6.2.5 have been renumbered 10.2.1 to 10.2.5.

6.3 10.3 Size of relief valves

Existing paragraphs 6.3.1 to 6.3.4 have been renumbered 10.3.1 to 10.3.4.

Part 5, Chapter 2

6-4 10.4 Vent pipes

Existing paragraphs 6.4.1 to 6.4.3 have been renumbered 10.4.1 to 10.4.3.

6-5 10.5 Warning notice

Existing paragraph 6.5.1 has been renumbered 10.5.1.

6-6 10.6 Crankcase access and lighting

Existing paragraphs 6.6.1 and 6.6.2 have been renumbered 10.6.1 and 10.6.2.

6-7 10.7 Fire-extinguishing system for scavenge manifolds

Existing paragraphs 6.7.1 has been renumbered 10.7.1.

6-8 10.8 Oil mist detection

Existing paragraphs 6.8.1 to 6.8.15 have been renumbered 10.8.1 to 10.8.15.

■ Section 18 11
Program for trials of diesel engines to assess operational capability

Existing sub-Sections 18.1 and 18.2 have been renumbered 11.1 and 11.2.

■ Section 9 12
Component tests and engine type testing

9-4 12.1 Hydraulic tests

Table 2-9.1 2.12.1 Test pressures for oil engine components (Part only shown)

NOTES
1. <i>p</i> is the maximum working pressure in the item concerned.
2. Pumps used in jerk or timed pump systems need only have the assembled high pressure-containing components hydraulically tested.
3. Turbo-charger air coolers need only be tested on the water side.
4. For forged steel cylinder covers and piston crowns alternative testing methods may be specially considered.
5. For hydraulic systems where design features are such that modifications to the test requirements are necessary, alternative proposals for hydraulic tests are to be submitted for special consideration.
6. Where components are subjected to an autofrettage process approved by LR, the component test pressure may be omitted. The assembled system containing such components is to be shown, where practicable, to be pressure-tight as required for Hydraulic systems.

Existing paragraphs 9.1.1 and 9.1.2 have been renumbered 12.1.1 and 12.1.2.

9-2 12.2 Alignment gauges

9-2.1 12.2.1 All main and auxiliary oil engines exceeding 220 kW (300 shp) are to be provided with an alignment gauge which may be either a bridge wear-down gauge, or a micrometer clock gauge for use between the crankwebs. Only one micrometer clock gauge need be supplied for each ship provided the gauge is suitable for use on all engines.

12.3 Auto fretting

- 12.3.1 The following documents and information are to be submitted in support of components subject to autofrettage:
- (a) Drawings and other related documents/information, including material grade, dimensions and autofrettage pressure.
 - (b) Calculations and tests undertaken to define pressures, times and other parameters relevant for the autofrettage process.
 - (c) Calculations and tests verifying increased fatigue endurance of components treated by autofrettage.
 - (d) Place of manufacture and sub-suppliers.
 - (e) Description of manufacturing QA process including control of suppliers.
 - (f) Description detailing how repeatability and reliability of autofrettage process is achieved.
 - (g) Methods and documents for recording results.
 - (h) Finished component and/or system testing.

12.3.2 LR certificates are to be issued for components subject to autofrettage, provided the attending Surveyors are satisfied that the accepted QA process has been applied.

9-3 Engine type testing

Existing sub-Section 9.3 has been renumbered 17.1.

■ Section ~~11~~ 13 Mass produced engines

~~11.1~~ 13.1 Definition

Existing paragraphs 11.1.1 to 11.1.4 have been renumbered 13.1.1 to 13.1.4.

~~11.2~~ 13.2 Procedure for approval of mass produced engines

Existing paragraphs 11.2.1 to 11.2.5 have been renumbered 13.2.1 to 13.2.5.

~~11.3~~ 13.3 Continuous review of production

Existing paragraphs 11.3.1 and 11.3.2 have been renumbered 13.3.1 and 13.3.2.

~~11.4~~ 13.4 Compliance and inspection certificate

Existing paragraphs 11.4.1 and 11.4.2 have been renumbered 13.4.1 and 13.4.2.

■ Section ~~10~~ 14 Turbo-chargers

~~10.1~~ Plans and particulars

Existing sub-Section 10.1 has been deleted.

~~10.2~~ Type test

Existing sub-Section 10.2 has been renumbered 17.3.

~~10.3~~ 14.1 Dynamic balancing

Existing paragraph 10.3.1 has been renumbered 14.1.1.

~~10.4~~ 14.2 Overspeed test

Existing paragraph 10.4.1 has been renumbered 14.2.1.

~~10.5~~ 14.3 Mechanical running test

Existing paragraphs 10.5.1 to 10.5.2 have been renumbered 14.3.1 to 14.3.2.

■ Section ~~12~~ 15 Mass produced turbo-chargers

~~12.1~~ 15.1 Application

Existing paragraph 12.1.1 has been renumbered 15.1.1.

~~15.2~~ Plans and particulars

Existing sub-Section 15.2 has been deleted.

~~12.2~~ 15.2 Procedure for approval of mass produced turbo-chargers

Existing paragraphs 12.2.1 to 12.2.5 have been renumbered 15.2.1 to 15.2.5.

~~12.3~~ 15.3 Continuous inspection of individual units

Existing paragraphs 12.3.1 to 12.3.7 have been renumbered 15.3.1 to 15.3.7.

~~12.3.6~~ 15.3.6 Dynamic balancing and overspeed tests are to be carried out, see ~~10.3~~ 14.3 and ~~10.4~~ 14.4, in accordance with the approved procedure for quality control. If each forged wheel is individually controlled by an approved non-destructive examination method, then no overspeed test may be required except for wheels of the type test unit.

~~12.4~~ 15.4 Compliance and certificate

Existing paragraph 12.4.1 has been renumbered 15.4.1.

Existing Section 16 has been deleted.

■ Section 16 ~~Alarms and safeguards for emergency diesel engines~~

Existing Section 16 has been deleted.

■ Section 8 16 Air compressors and starting arrangements

Existing sub-Sections 8.1 to 8.10 have been renumbered 16.1 to 16.10.

Section 17

Type testing – General

9.3 17.1 Engines type testing

Existing paragraphs 9.3.1 to 9.3.6 have been renumbered 17.1.1 to 17.1.6.

**11.5 17.2 Type test conditions
Mass produced engines**

Existing paragraphs 11.5.1 to 11.5.12 have been renumbered 17.2.1 to 17.1.12.

10.2 17.3 Type test Turbo-chargers

Existing paragraphs 10.2.1 and 10.2.2 have been renumbered 17.3.1 and 17.3.2.

Section 18

**Type testing procedure for
crankcase explosion relief valves**

13.1 18.1 Scope

Existing paragraphs 13.1.1 and 13.1.2 have been renumbered 18.1.1 and 18.1.2.

13.2 18.2 Purpose

Existing paragraph 13.2.1 has been renumbered 18.2.1.

13.3 18.3 Test facilities

Existing paragraph 13.3.1 has been renumbered 18.3.1.

13.4 18.4 Explosion test process

Existing paragraphs 13.4.1 to 13.4.4 have been renumbered 18.4.1 to 18.4.4.

13.5 18.5 Valves to be tested

Existing paragraphs 13.5.1 to 13.5.4 have been renumbered 18.5.1 to 18.5.4.

13.6 18.6 Method

Existing paragraphs 13.6.1 to 13.6.5 have been renumbered 18.6.1 to 18.6.5.

13.7 18.7 Assessment and records

Existing paragraph 13.7.1 has been renumbered 18.7.1.

13.8 18.8 Design series qualification

Existing paragraphs 13.8.1 to 13.8.4 have been renumbered 18.8.1 to 18.8.4.

13.9 18.9 The report

Existing paragraph 13.9.1 has been renumbered 18.9.1.

13.10 18.10 Approval

Existing paragraph 13.10.1 has been renumbered 18.10.1.

Section 19

**Type testing procedure for
crankcase oil mist detection and
alarm equipment**

14.1 19.1 Scope

Existing paragraphs 14.1.1 and 14.1.2 have been renumbered 19.3.1 and 19.3.2.

14.2 19.2 Purpose

Existing paragraph 14.2.1 has been renumbered 19.2.1.

14.3 19.3 Test facilities

Existing paragraph 14.3.1 has been renumbered 19.3.1.

14.4 19.4 Equipment testing

Existing paragraphs 14.4.1 and 14.4.2 have been renumbered 19.4.1 and 19.4.2.

14.5 19.5 Functional tests

Existing paragraphs 14.5.1 to 14.5.8 have been renumbered 19.5.1 to 19.5.8.

14.6 19.6 Detectors and alarm equipment to be tested

Existing paragraphs 14.6.1 and 14.6.2 have been renumbered 19.6.1 and 19.6.2.

14.7 19.7 Method

Existing paragraphs 14.7.1 to 14.7.5 have been renumbered 19.7.1 to 19.7.5.

14.8 19.8 Assessment

Existing paragraph 14.8.1 has been renumbered 19.8.1.

14.9 19.9 Design series qualification

Existing paragraph 14.9.1 has been renumbered 19.9.1.

~~14.10~~ 19.10 The report

Existing paragraph 14.10.1 has been renumbered 19.10.1.

~~14.11~~ 19.11 Acceptance

Existing paragraphs 14.11.1 and 14.11.2 have been renumbered 19.11.1 and 19.11.2.

Part 5, Chapter 3 Steam Turbines

Effective date 1 July, 2012

■ Section 4 Safety arrangements

4.1 Overspeed protective devices

~~4.1.1 An overspeed protective device is to be provided for main and auxiliary turbines to shut off the steam automatically and prevent the maximum designed speed being exceeded by more than 15 per cent.~~

~~4.1.2 Where two or more turbines of a compound main turbine installation are separately coupled to the same main gear wheel, and one overspeed protective device is provided, this is to be fitted to the L.P. ahead turbine. Hand trip gear for shutting off the steam in an emergency is to be provided at the manoeuvring platform.~~

4.2 Speed governors

~~4.2.1 Where a turbine installation incorporates a reverse gear, electric transmission or reversible propeller, a speed governor in addition to, or in combination with, the overspeed protective device is to be fitted, and is to be capable of controlling the speed of the unloaded turbine without bringing the overspeed protective device into action.~~

~~4.2.2 Auxiliary turbines intended for driving electric generators are to be fitted with speed governors which, with fixed setting, are to control the speed within 10 per cent momentary variation and 5 per cent permanent variation when full load is suddenly taken off or put on. The permanent speed variations of alternating current machines intended for parallel operations are to equalise within a tolerance of ± 0.5 per cent.~~

~~4.3.1~~ 4.1 Low vacuum and overpressure protective devices

~~4.3.1~~ ~~4.1.1~~ In order to provide a warning, due to excessive pressure, to personnel in the vicinity of the exhaust ends of main turbines, sentinel relief valves are to be provided at the exhaust ends or other approved positions. The relief valve discharge outlets are to be visible and suitably guarded if necessary. Where a low vacuum cut-out device is provided, the sentinel relief valve at the L.P. exhaust may be omitted.

~~4.3.2~~ ~~4.1.2~~ In order to provide a warning, due to excessive pressure, to personnel in the vicinity of the exhaust ends of auxiliary turbines, sentinel relief valves are to be provided at the exhaust ends. The relief valve discharge outlets are to be visible and suitably guarded if necessary. Low vacuum or overpressure cut-out devices, as appropriate, are also to be provided for auxiliary turbines not installed with their own condensers.

4.4 ~~4.2~~ Bled steam connections

~~4.4.1~~ ~~4.2.1~~ Non-return or other means, which will prevent steam and water returning to the turbines, are to be fitted in bled steam connections.

4.5 ~~4.3~~ Steam strainers

~~4.5.1~~ ~~4.3.1~~ Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines, or alternatively at the inlets to the manoeuvring valves.

■ Section 6 Control and monitoring of main and auxiliary steam turbines

6.1 General

~~6.1.1~~ Control engineering systems are to be in accordance with the requirements of Pt 6, Ch 1.

6.1.2 All main and auxiliary steam turbines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such turbines are of more than 37 kW (50 shp), audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

6.2 Overspeed protective devices

6.2.1 An overspeed protective device is to be provided for main and auxiliary turbines to shut off the steam automatically and prevent the maximum designed speed being exceeded by more than 15 per cent.

6.2.2 Where two or more turbines of a compound main turbine installation are separately coupled to the same main gear wheel, and one overspeed protective device is provided, this is to be fitted to the L.P. ahead turbine. Hand trip gear for shutting off the steam in an emergency is to be provided at the manoeuvring platform.

6.3 Speed governors

6.3.1 Where a turbine installation incorporates a reverse gear, electric transmission or reversible propeller, a speed governor in addition to, or in combination with, the overspeed protective device is to be fitted, and is to be capable of controlling the speed of the unloaded turbine without bringing the overspeed protective device into action.

6.3.2 Auxiliary turbines intended for driving electric generators are to be fitted with speed governors which, with fixed settings, are to control the speed within 10 per cent momentary variation and 5 per cent permanent variation when full load is suddenly taken off or put on. The permanent speed variations of alternating current machines intended for parallel operations are to equalise within a tolerance of $\pm 0,5$ per cent.

6.4 Unattended machinery

6.4.1 Where machinery steam turbines are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms and safety arrangements required by 6.4 to 6.6, as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

6.4.2 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start-up under conditions which could hazard the machinery.

6.4.3 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

6.4.4 Where a first stage alarm together with a second stage alarm and automatic shut-down of machinery are required in the relevant Tables of this Section, the sensors and circuits utilised for the second stage alarm and automatic shut-down are to be independent of those required for the first stage alarm.

6.5 Steam turbine machinery for propulsion purposes

6.5.1 Alarms and safeguards are indicated in 6.5.2 to 6.5.6 and Table 3.6.1.

6.5.2 Audible and visual alarms are to operate, and indication is to be given at the relevant control stations to stop or reduce the speed of the turbine(s) for the following fault conditions:

- (a) Excessive turbine vibration.
- (b) Excessive axial movement of turbine rotor.
- (c) Low vacuum in main condenser.
- (d) High condensate level in main condenser.

6.5.3 Reduction of speed may be effected by either manual or automatic control.

6.5.4 Means are to be provided to prevent the risk of thermal distortion of the turbines, by automatic steam spinning, when the shaft is stopped in the manoeuvring mode. An audible and visual alarm is to be provided at the relevant control stations when the shaft has been stopped for a predetermined time.

6.5.5 The following turbine services are to be fitted with automatic controls so as to maintain steady state conditions throughout the normal operating range of the propulsion turbine(s):

- (a) Lubricating oil supply temperature.
- (b) Condenser condensate level.
- (c) Gland steam pressure.

6.5.6 Prolonged running in a restricted speed range is to be prevented automatically, or alternatively, indication of restricted speed ranges is to be provided at each control station.

6.6 Auxiliary steam turbines

6.6.1 Alarms and safeguards are indicated in Table 3.6.2.

Existing Section 6 has been renumbered Section 7.

Table 3.6.1 Steam turbine machinery: Alarms and safeguards

Item	Alarm	Note
Lubricating oil pressure	1st stage low 2nd stage low	— Automatic shut-down, see 6.4.4
Lubricating oil temperature	High	—
Lubricating oil sump level	Low	—
Lubricating oil filters differential pressure	High	—
Bearing temperatures or bearing oil outlet temperature	High	—
Astern turbine temperature	High	—
Gland steam pressure	High and Low	—
Thrust bearing temperature	High	—
Sea-water pressure or flow	Low	—
Turbine vibration	High	—
Axial movement of turbine rotor	High	Shut-down or speed reduction or turbine(s)
Main condenser vacuum	Low	—
Main condenser condensate level	High	—
Overspeed	High	See 6.2

Table 3.6.2 Auxiliary engines and auxiliary steam turbines: Alarms and safeguards

Item	Alarm	Note
Lubricating oil inlet temperature	High	—
Lubricating oil inlet pressure	1st stage low 2nd stage low	— Automatic shut-down of turbine, see 6.4.4
Condenser vacuum	Low	Automatic shut-down of turbine, see 6.4.4
Axial displacement of rotor	High	—
Overspeed	High	See Ch 4,4

Part 5, Chapter 4

Gas Turbines

Effective date 1 July, 2012

Section 8

Control, alarm and safety systems

8.1 General

8.1.2 All gas turbines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such turbines are of more than 37 kW (50 shp), audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

8.8 Unattended machinery

8.8.1 Where gas turbines are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms and safety arrangements required by 8.8 to 8.9 as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

8.8.2 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start-up under conditions which could hazard the machinery.

8.8.3 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

Part 5, Chapter 4

8.8.4 Where a first stage alarm together with a second stage alarm and automatic shut-down of machinery are required in the relevant Tables of this Section, the sensors and circuits utilised for the second stage alarm and automatic shut-down are to be independent of those required for the first stage alarm. LR will consider alternative arrangements which provide an equivalent level of safety.

8.9 Gas turbine machinery

8.9.1 Alarms and safeguards are indicated in 8.9.2 to 8.9.4 and Table 4.8.1.

8.9.2 The following turbine services are to be fitted with automatic temperature controls so as to maintain steady state conditions throughout the normal operating range of the turbine:

- (a) Lubricating oil supply.
- (b) Oil fuel supply, *see also* 8.9.3.
- (c) Exhaust gas.

8.9.3 The oil fuel supply may be fitted with an automatic control for viscosity instead of the temperature control required by 8.9.2.

8.9.4 A means of manually shutting off the fuel in an emergency is to be provided at the manoeuvring station.

Table 4.8.1 Gas turbine machinery: Alarms and safeguards

Item	Alarm	Note
Overspeed	High	Automatic shut-down <i>see also</i> 8.2
Power turbine inlet temperature	1st stage high	Automatic power reduction
	2nd stage high	Automatic shut-down <i>see also</i> 8.3
Flame failure	Failure	Automatic shut-down, <i>see also</i> 8.4
Failure to ignite	Failure	Automatic shut-down, <i>see also</i> 8.4
Lubricating oil pressure	1st stage low	—
	2nd stage low	Automatic shut-down, <i>see also</i> 8.5
Lubricating oil temperature	High	<i>See also</i> 8.5
Lubricating oil filter differential pressure	High	—
Scavenge oil temperature	High	—
Scavenge oil pressure	Low	Automatic shut-down
Bearing temperature	High	—
Turbine vibration	1st stage high	—
	2nd stage high	Automatic shut-down, <i>see also</i> 4.2
Oil fuel supply pressure	Low	—
Oil fuel supply temperature	High	—
Oil fuel leakage	High	<i>See also</i> 5.2
Automatic starting	Failure	Automatic shut-down
Control system	Failure	Automatic shut-down
Air intake pressure	Low	<i>See also</i> 4.4.4
Feed water or water/thermal fluid forced circulation flow (if fitted)	Low	<i>See</i> Ch 14,6.2.7 and Note 4
Uptake temperature	High	To monitor for soot fires. <i>See</i> Notes 4 and 5

NOTES

1. For two-stage alarms, *see also* 8.8.4.
2. For requirements on purging before ignition, *see* Ch 4,6.2.1.
3. Where a requirement for disabling the automatic protection and safety system devices for machinery and engineering systems has been defined by the Owner, the consequences of using the disabling arrangements are to be established and included in the operations procedures and orders provided on board ship. Details of any disabling arrangements are to be submitted to LR for consideration in each instance.
4. Alarm is required only when suitable for operation on residual fuel grades and an exhaust gas economiser/boiler/thermal oil heater is fitted.
5. Alternatively, details of an appropriate fire detection system are to be submitted for consideration.

Part 5, Chapter 5

Gearing

Effective date 1 July, 2012

Section 3 Design

3.7 Design of enclosed gear shafting

3.7.1 This sub-Section is applicable to shafting enclosed within the gearcase. Final gear wheel shafts and thrust shafts are to be in accordance with Ch 6,3.3 and Ch 6,3.4 respectively.

3.7.2 The diameter of the enclosed gear shafting adjacent to the pinion or wheel is to be not less than the greater of d_b or d_t , where:

$$d_b = 365 \left(\frac{P L}{R d_w S_b} \right)^{1/3} \left(1 + \left(\frac{\tan \alpha_n}{\cos \beta} + \frac{\tan \beta d_w}{L} \right)^2 \right)^{1/6}$$

$$d_t = 365 \left(\frac{P}{R S_s} \right)^{1/3}$$

where

$$S_b = 45 + 0,24 (\sigma_u - 400) \text{ and}$$

$$S_s = 42 + 0,09 (\sigma_u - 400)$$

L = span between shaft bearing centres, in mm

α_n = normal pressure angle at the gear reference diameter, in degrees

β = helix angle at the gear reference diameter, in degrees

d_w = pitch circle diameter of the gear teeth, in mm

σ_u = specified minimum tensile strength of the shaft material, in N/mm².

NOTE

P in kW and R in rpm are as defined in Ch 1,3.3.

Numerical value used for σ_u is not to exceed 800 N/mm² for gear and thrust shafts.

3.7.3 For the purposes of the above it is assumed that the pinion or wheel is mounted symmetrically spaced between bearings.

3.7.4 Outside a length equal to the required diameter at the pinion or wheel, the diameter may be reduced, if applicable, to that required for d_t .

3.7.5 For bevel gear shafts, where a bearing is located adjacent to the gear section, the diameter of the shaft is be not less than d_t . Where a bearing is not located adjacent to the gear the diameter of the shaft will be specially considered.

Section 6 Control and monitoring

6.1 General

6.1.1 Control engineering systems are to be in accordance with Pt 6, Ch 1.

6.1.2 All main and auxiliary gear units intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

6.2 Unattended machinery

6.2.1 Where machinery is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, it is to be provided with the alarms and safety arrangements required by 6.2, as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

6.2.2 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

6.2.3 Where a first stage alarm together with a second stage alarm and automatic shut-down of machinery are required in the relevant Tables of this Section, the sensors and circuits utilised for the second stage alarm and automatic shut-down are to be independent of those required for the first stage alarm.

6.2.4 Alarms and safeguards are indicated in Table 5.6.1.

Table 5.6.1 Main and auxiliary gear units: Alarms and safeguards

Item	Alarm	Note
Lubricating oil sump level	Low	—
Lubricating oil inlet pressure	1st stage low	Slow-down
Lubricating oil inlet pressure	2nd stage low	Automatic shut-down
Lubricating oil inlet temperature	High	—
Thrust bearing temperature	High	Slow-down
NOTE		
For transmitted powers of 1500 kW or less, only the items marked * are required.		

Part 5, Chapter 6

Main Propulsion Shafting

Effective date 1 July, 2012

■ Section 3

Design

3.12 Sternbushes

3.12.8 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. ~~Means for ascertaining the temperature of the oil in the sterntube are also to be provided.~~

3.12.9 Two temperature sensors or other approved arrangements that can, where practicable, be replaced without dry-docking or divers are to be provided to ascertain the sterntube aft end bearing temperature.

Existing paragraphs 3.12.9 to 3.12.11 have been renumbered 3.12.10 to 3.12.12.

Part 5, Chapter 7

Propellers

Effective date 1 July, 2012

■ Section 5

Control and monitoring

5.1 General

5.1.1 Control engineering systems are to be in accordance with the requirements of Pt 6, Ch 1.

5.2 Unattended machinery

5.2.1 Where controllable pitch propellers are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms and safety arrangements required by 5.2 to 5.3, as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

5.2.2 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

5.3 Controllable pitch propellers and transverse thrust units

5.3.1 Alarms and safeguards are indicated in 5.3.2 to 5.3.5 and Table 7.5.1. For azimuth thrusters, see also Chapter 20.

5.3.2 For controllable pitch propellers for main propulsion, a standby or alternative power source of actuating medium for controlling the pitch of the propelling blades is to be provided. Automatic start of the standby pump supplying hydraulic power for pitch control is to be provided.

5.3.3 Controllable pitch propellers for main propulsion are to be provided with indications of shaft speed, direction and magnitude of thrust and propeller pitch as a measure of the propeller blade or actuator movement at each station from which it is possible to control shaft speed or propeller pitch.

5.3.4 Where transverse thrust units are remotely controlled, means are to be provided at the remote control station to stop the propulsion unit.

5.3.5 Transverse thrust units are to be provided with indications of direction and magnitude of thrust and propeller pitch at each station from which it is possible to control the propeller pitch.

Table 7.5.1 Controllable pitch propellers and transverse thrust units: Alarms and safeguards

Item	Alarm	Note
Hydraulic system pressure	Low	—
Hydraulic oil supply tank level	Low	—
Hydraulic oil temperature	High	Where an oil cooler is fitted
Power supply to the control system between the remote control station and hydraulic actuator	Failure	See Pt 6, Ch 1,2.5.3

Part 5, Chapter 10

Steam Raising Plant and Associated Pressure Vessels

Effective date 1 July, 2012

■ **Section 15**
Mountings and fittings for cylindrical and vertical boilers, steam generators, pressurised thermal liquid and pressurised hot water heaters

15.11 Salinometer Sampling valve or cock

15.11.1 Each boiler is to be provided with a salinometer sampling valve or cock secured direct to the boiler in a convenient position. The valve or cock is not to be on the water gauge standpipe.

■ **Section 18**
Control and monitoring

18.1 General

18.1.1 Control engineering systems are to be in accordance with the requirements of Pt 6, Ch 1.

18.2 Unattended machinery

18.2.1 Where boilers are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms and safety arrangements required by 18.2 to 18.3, as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

18.2.2 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start-up under conditions which could hazard the machinery.

18.2.3 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

18.2.4 Where a first stage alarm together with a second stage alarm and automatic shut-down of machinery are required in the relevant Tables of this Section, the sensors and circuits utilised for the second stage alarm and automatic shut-down are to be independent of those required for the first stage alarm.

18.3 Main, auxiliary and other boilers

18.3.1 Alarms and safeguards are indicated in 18.3.2 to 18.3.9 and Table 10.18.1.

18.3.2 The following boiler services are to be fitted with automatic controls so as to maintain steady state conditions throughout the normal operating range of the boiler:

- (a) Combustion system.
- (b) Oil fuel supply temperature or viscosity, heavy oil only.
- (c) Boiler drum water level.
- (d) De-aerator water level, where applicable.
- (e) Superheated steam pressure, where applicable.
- (f) Superheated steam temperature, where applicable.
- (g) De-superheated steam pressure, where applicable.
- (h) De-superheated steam temperature, where applicable.

18.3.3 Safety systems and overrides are to comply with the requirements of Pt 6, Ch 1,2.4.9.

18.3.4 Burner controls are to be arranged such that light off is only possible at the minimum firing rate compatible with flame establishment. If ignition is set to occur at a fuel rich condition then the burner is to revert to the correct operating air/fuel ratio on establishment of a stable flame.

18.3.5 Where water level indicators are dependent upon an external power supply, the oil fuel supply to the burners is to be automatically shut off in the event of power or signal failure.

18.3.6 Arrangements are to be such that burner oil fuel valve(s) do not open:

- (a) prior to completion of required warm up times for residual fuel oil; or
- (b) when the power supply to the igniter has failed, as applicable; or
- (c) until a pilot flame is established, as applicable; or
- (d) prior to the completion of furnace purging, see Ch 14,3.1.7.

18.3.7 Arrangements for flame failure detection are to be provided with self-monitoring capabilities which ensure that the flame detector is not erroneously indicating the presence of a flame. In the event of failure being detected by these self-monitoring capabilities:

- an alarm is to be activated;
- in the event of loss of flame detection capability for a burner;
- oil fuel to the burner is to be shut off automatically; and
- an alarm is to be activated.

18.3.8 Where established as necessary by Ch 14,3.1.8, means are to be provided to prevent starting of the ignition sequence following multiple flame failures until completion of the identified lock-out period.

18.3.9 Following burner shut-down, the furnace is to be purged automatically for at least the required pre-purging time. In the event of shut-down due to activation of a required safeguard, this purging is to be manually initiated.

Table 10.18.1 Main, auxiliary and other boilers: Alarms and safeguards (see continuation)

Item	Alarm	Note
Water level*	Low	Two water level sensors are to be provided, each to operate independently, and automatically to shut off the oil fuel to the burners and operate alarms, see Notes 1 to 3 and 5
Water level	1st stage high 2nd stage high	— Where applicable, automatic closure of turbine steam inlet valves, see 18.2.4
Steam drum or superheater outlet pressure*	High and Low	—
Superheated steam temperature	High	—
De-superheated steam temperature*	High	—
Feed water or water forced circulation flow (if fitted)	Low	Oil fuel to burners to be shut off automatically, see Notes 5 and 6
Feed water pH	Low	When automatic dosing of feed water fitted
Feed water salinity	High	Fitted in boiler feed system
Feed water temperature	Low	When automatic temperature control fitted
Combustion air pressure*	Low	Oil fuel burners to be shut off automatically in operation or not released during start up, see Note 5. Purge sequences to be inhibited, see Ch 14,3.1.7
Oil fuel pressure*	Low	—
Oil fuel temperature or viscosity*	High and Low	Heavy oil only
Oil fuel atomising steam/air pressure	Low	—
Burner flame*	Failure	Each burner to be monitored. Oil fuel to burner(s) to be shut off automatically, see Ch 14,3.1.9 and 3.1.10 and Note 5
Flame monitoring device(s)*	Failure	See 18.3.7 and Note 5
Igniter power supply	Failure	Each igniter to be checked before oil fuel is supplied to burner, see 18.3.6 and Note 5
Forced draft fan*	Power failure	Oil fuel to burners to be shut off automatically. Control using alternative arrangements is to remain available, see Pt 6, Ch 1,2.5.8
Air registers and dampers (including those in the uptake)*	Not fully open	Purge sequence to be inhibited, see Ch 14,3.1.7
Control system*	Power failure	Oil fuel burners to be shut off automatically. Control using alternative arrangement is to remain available, see Pt 6, Ch 1,2.5.8
Uptake temperature	High	Where economiser and/or gas air heaters are integral with the boiler and also for independent exhaust gas boilers/economisers, to monitor for soot fires. See Note 7

NOTES

- For dual-evaporation boilers, the primary circuit is to be fitted with two independent low water level detectors which will operate alarms and shut off the oil fuel to the burners automatically. The secondary circuit is to be fitted with one low water level detector which will operate alarms and shut off the oil fuel to the burners automatically. Additionally one high water level alarm is to be fitted on the secondary circuit which may be operated by the same detector as that provided for low water level detection.
- Only one independent system of low water level detection, alarm and automatic oil fuel shut-off need be fitted in the case of small forced circulation or re-circulation coiled water tube 'package' type boilers when evaporation is less than 2900 kg/hr or the heating surface is less than 100 m².
- Where two level sensors are provided these may be used for other functions, e.g., high level alarm, level control, trip systems, etc.
- For boilers not supplying steam for propulsion or for services essential for the safety or operation of the ship at sea, only the items marked * are required.
- These safeguards are to remain operative during automatic, manual and emergency operation.
- For exhaust gas economisers/boilers requiring feed water or forced water circulation, the low flow alarm is to be fitted with provision to override the alarm if the exhaust gas economiser/boiler is to be operated in the dry condition. See also Ch 14,6.2.5.
- Alternatively, details of an appropriate fire detection system are to be submitted for consideration.

Part 5, Chapter 11

Other Pressure Vessels

Effective date 1 July, 2012

■ Section 1

General requirements

1.6 Plans

1.6.1 Plans of pressure vessels are to be submitted in triplicate for consideration where all the conditions in (a) or (b) are satisfied:

- (a) The vessel contains vapours or gases, e.g. air receivers, hydrophore or similar vessels and gaseous CO₂ vessels for fire-fighting, and
 - $pV > 600$
 - $p > 1$
 - $V > 100$
 - V = volume (litres) of gas or vapour space
- (b) The vessel contains liquefied gases, ~~for fire-fighting or flammable liquids, and~~
 - $p > 7$
 - $V > 100$
 - V = volume (litres)
 - p is as defined in 1.2.1.

Part 5, Chapter 12

Piping Design Requirements

Effective date 1 July, 2012

■ Section 1

General

1.6 Materials

1.6.2 The manufacturer's certificate validated by LR for materials for pipes, valves and fittings of Class I and Class II piping systems will be accepted in lieu of LR's materials certificate where the maximum conditions are less than either of the values shown in Table 12.1.2. See Ch 1,3.1.3(b) of the Rules for Materials.

■ Section 2

Carbon and low alloy steels

2.9 Welded sleeve joints

2.9.5 The thickness of the sleeve is to satisfy the requirements of 2.2.3 and Table 12.2.4 but is to be not less than 1,42 times the nominal thickness of the pipe in order to satisfy the throat thickness requirement in 2.9.6. The radial clearance between the outside diameter of the pipe and the internal diameter of the sleeve is not to exceed 1 mm for pipes up to

a nominal diameter of 50 mm, 2 mm on diameters up to 200 mm nominal size and 3 mm for larger size pipes. The pipe ends are to be separated by a clearance of approximately 2 mm at the centre of the sleeve. Alternatively, consideration will be given to sleeve thickness in accordance with a relevant National Standard.

■ Section 8

Hydraulic tests on pipes and fittings

8.1 Hydraulic tests before installation on board

8.1.1 All Class I and II pipes and their associated fittings are to be tested by hydraulic pressure to the Surveyor's satisfaction. Further, all steam, feed, compressed air and oil fuel pipes, together with their fittings, are to be similarly tested where the design pressure is greater than ~~3,5 bar (3,6 kgf/cm²)~~ 7,0 bar. The test is to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

Section 9

Piping for LPG/LNG carriers, gas fuelled ships and classed refrigeration systems

9.4 Materials

9.4.3 For stainless steel pipes, valve castings and forgings intended for service temperatures down to minus 55°C, a LR Materials Certificate is required unless ~~the nominal diameter is less than 50 mm, or the nominal diameter is less than 150 mm and working pressure, in bar g, multiplied by nominal diameter, in mm, is less than 2500, where a manufacturer's material certificate is acceptable.~~

- $DN < 50$ or
- $DN \leq 150$ and $DN \times P < 2500$

where a manufacturer's certificate is acceptable.

9.7 Valves for refrigeration service

9.7.1 For valves intended for installation in a refrigeration system with a nominal diameter ~~of equal to or less than~~ 150 mm, a manufacturer's certificate is acceptable. The certificate is to include details of the maximum working pressure and test pressure, and sufficient information for the LR Surveyor to assess the suitability of the equipment for the intended use. Each size and type of valve is to be supplied with its own certificate and is to be signed by a responsible person in the manufacturer's quality control department.

9.11 Relief valves for LPG/LNG cargo and deck tanks

9.11.1 Relief valves fitted to cargo tanks and deck tanks are to be of a type tested design. Type testing is to include:

- flow or capacity verification to a recognised Standard acceptable to the Administration;
- cryogenic testing when operating at design temperatures colder than minus 55°C;
- seat tightness testing to a recognised Standard or manufacturers' procedure acceptable to the Administration; and
- pressure testing of pressure-containing parts to at least 1,5 times the design pressure.

9.11.2 The materials used for construction of relief valves fitted to cargo tanks and deck tanks are to be produced in a works approved by LR and be provided with a Lloyd's Register Material Certificate.

Part 5, Chapter 13 Ship Piping Systems

Effective date 1 July, 2012

Section 5

Sizes of bilge suction pipes

5.1 Main bilge line

5.1.1 The diameter, d_m , of the main bilge line is to be not less than required by the following formula, to the nearest 5 mm, but in no case is the diameter to be less than that required for any branch bilge suction:

$$d_m = 1,68 \sqrt{L(B + D)} + 25 \text{ mm}$$

where

d_m = internal diameter of main bilge line, in mm

B = greatest moulded breadth of ship, in metres ~~or maximum breadth of cargo hold for ore carriers, in metres~~

D = moulded depth to bulkhead deck, in metres

L = Rule length of ship as defined in Pt 3, Ch 1,6.1, in metres, for ships other than passenger ships
= length between perpendiculars at the extremities of the deepest subdivision load line, in metres, for passenger ships.

Section 6

Pumps on bilge service and their connections

6.1 Number of pumps

~~6.1.7 Where the bilge pumps required by 6.1.1 or 6.1.5 are installed in spaces not fitted with a double bottom, the pumps are to be either:~~

- ~~capable of operating in flooded spaces; or~~
- ~~located in separate watertight compartments.~~

Part 5, Chapter 14

Machinery Piping Systems

Effective date 1 July, 2012

■ Section 2

Oil fuel – General requirements

2.10 Oil fuel contamination

~~2.10.4 The piping arrangements for gas oil, distillate and diesel grades are to be separate and distinct from those intended for residual grades, up to the service tanks required by 4.18, to prevent cross-contamination. Piping arrangements or alternative means are to be provided to ensure that distillates (i.e. gas oils/diesel grades) are to be kept separate and distinct from residual grades, up to the service tanks required by 4.18, in order to prevent cross-contamination. Cross-connection is permitted between separate arrangements in the event of failure of a designated item of equipment.~~

■ Section 8

Lubricating oil systems

8.1 General requirements

~~8.1.1 In addition to the requirements detailed in this Section, the requirements of Sections 2 and 4 are to be complied with in so far as they are applicable. In all cases 2.0.1 to 2.0.3, 4.2, 4.3, 4.5, 4.8, 4.11 and 4.17 are to apply. The arrangements for storage, distribution and utilisation of lubricating oils are to comply with the requirements of this Section.~~

8.3 Alarms

~~8.3.1 All main and auxiliary engines and turbines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines and turbines are of more than 37 kW (50 shp), audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.~~

8.3 Control of pumps

8.3.1 The power supply to all independently driven lubricating oil transfer and pressure pumps is to be capable of being stopped from a position outside the space, which will always be accessible in the event of fire occurring in the compartment in which they are situated, as well as from the compartment itself.

8.4 Relief valves on pumps

8.4.1 All lubricating oil pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves or equivalent. Each relief valve is to be in closed circuit, i.e., arranged to discharge back to the suction side of the pump, thereby limiting the pump discharge pressure to the design pressure of the system.

8.4.2 Where centrifugal type lubricating oil pumps are fitted, pressure relief valves will not be required, provided that pipes, valves and fittings are suitable for the greater of the design pressure or pump non-delivery pressure.

Existing sub-Sections 8.4 to 8.6 have been renumbered 8.5 to 8.7.

8.8 Filling arrangements

8.8.1 Filling stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

8.8.2 Provision is to be made against over-pressure in the filling pipelines, and any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position, or an equivalent arrangement is to be provided, except filling by means of loose hose.

Existing sub-Section 8.7 has been renumbered 8.9.

8.10 Pipes conveying oil

8.10.1 Pipes conveying lubricating oil under pressure are to be of seamless steel or other approved material having flanged or welded joints, and are to be placed in sight above the platform in well lit and readily accessible parts of the machinery spaces. The number of flanged joints is to be kept to a minimum.

8.10.2 For requirements relating to flexible hoses, see Ch 12,7.

Existing sub-Sections 8.8 and 8.9 have been renumbered 8.11 and 8.12.

8.40 8.13 Deep tank valves and their control arrangements

~~8.10.1~~ 8.13.1 The requirements for remote operation of valves on deep tank suction pipes may be waived where the valves are closed during normal operation.

~~8.10.2~~ 8.13.2 Remotely operated valves on lubricating oil deep tank suction should not be of the quick-closing type where inadvertent use would endanger the safe operation of the main propulsion and essential auxiliary machinery.

8.13.3 Every lubricating oil suction pipe from a storage, settling and service tank situated above the double bottom, and every oil levelling pipe within the engine room, is to be fitted with a valve or cock secured to the tank.

8.13.4 Valves and cocks are to be capable of being closed locally and from positions outside the space in which the tank is located. The remote controls are to be accessible in the event of fire occurring in the deep tank's space. Instructions for closing the valves or cocks are to be indicated at the valves and cocks and at the remote control positions.

8.13.5 In the case of tanks of less than 500 litres, capacity, consideration will be given to the omission of remote controls.

8.13.6 Every lubricating oil suction pipe which is led into the engine space from a tank situated above the double bottom outside this space is to be fitted in the machinery space with a valve controlled as in 8.13.4, except where the valve on the tank is already capable of being closed from an accessible position above the bulkhead deck.

8.13.7 Where the filling pipes to deep lubricating oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks, fitted and controlled as in 8.13.4.

8.14 Separate oil tanks

8.14.1 On completion, the tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected.

8.15 Precautions against fire

8.15.1 Lubricating oil tanks and filters are not to be situated immediately above boilers or other highly heated surfaces.

8.15.2 Lubricating oil pipes are not to be installed above or near high-temperature equipment. Lubricating oil pipes should also be installed and screened or otherwise suitably protected, to avoid oil spray or oil leakages on to hot surfaces, into machinery air intakes, or other sources of ignition such as electrical equipment. Pipe joints are to be kept to a minimum and where provided are to be of a type acceptable to LR. Pipes are to be led in well lit and readily visible positions.

8.15.3 Pumps, filters and heaters are to be located to avoid lubricating oil spray or leakage on to hot surfaces or other sources of ignition, or on to rotating machinery parts. Where necessary, shielding is to be provided and the arrangements are to allow easy access for routine maintenance. The design of filter and strainer arrangements is to be such as to avoid the possibility of them being opened inadvertently when under pressure. This may be achieved either by mechanically preventing the pressurised filter from being opened or by providing pressure gauges which clearly indicate which filter is under pressure. In either case, suitable means for pressure release are to be provided, with drain pipes led to a safe location.

Section 9

Hydraulic systems

9.1 General

9.1.2 The arrangements for storage, distribution and utilisation of hydraulic and flammable oils employed in the systems defined in 9.1.1 are to comply with the provisions of 2.0.1 to 2.0.3, 4.3, 4.5, 4.11 and 4.17 where applicable requirements of this Section.

9.3 Relief valves on pumps

9.3.1 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be in closed circuit, i.e., arranged to discharge back to the suction side of the pump and effectively to limit the pump discharge pressure to the design pressure of the system.

9.4 Pipes conveying oil

9.4.1 Pipes conveying hydraulic oil under pressure are to be of seamless steel or other approved material having flanged or welded joints, and are to be placed in sight above the platform in well lit and readily accessible parts of the machinery spaces. The number of flanged joints is to be kept to a minimum.

9.4.2 For requirements relating to flexible hoses, see Ch 12,7.

9.5 Filling arrangements

9.5.1 Filling stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

9.5.2 Provision is to be made against over-pressure in the filling pipelines, and any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position, or an equivalent arrangement is to be provided, except filling by means of a loose hose.

9.6 Separate oil tanks

9.6.1 On completion, the tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected.

9.7 Precaution against fire

9.7.1 Hydraulic oil tanks and filters are not to be situated immediately above boilers or other highly heated surfaces.

9.7.2 Hydraulic oil pipes are not to be installed above or near high-temperature equipment. Hydraulic oil pipes should also be installed and screened or otherwise suitably protected, to avoid oil spray or oil leakages on to hot surfaces, into machinery air intakes, or other sources of ignition such as electrical equipment. Pipe joints are to be kept to a minimum and where provided are to be of a type acceptable to LR. Pipes are to be led in well lit and readily visible positions.

9.7.3 Pumps, filters and heaters are to be located to avoid hydraulic oil spray or leakage on to hot surfaces or other sources of ignition or on to rotating machinery parts. Where necessary, shielding is to be provided and the arrangements are to allow easy access for routine maintenance. The design of filter and strainer arrangements is to be such as to avoid the possibility of them being opened inadvertently when under pressure. This may be achieved either by mechanically preventing the pressurised filter from being opened or by providing pressure gauges which clearly indicate which filter is under pressure. In either case, suitable means for pressure release are to be provided, with drain pipes led to a safe location.

Section 12

Control, supervision and monitoring of machinery

12.1 General

12.1.1 Where machinery is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, it is to be provided with the alarms and safety arrangements required by 12.2 to 12.5, as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

12.1.2 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start-up under conditions which could hazard the machinery.

12.1.3 Where machinery specified in this Section is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

12.1.4 Where a first stage alarm together with a second stage alarm and automatic shut-down of machinery are required in the relevant Tables of this Section, the sensors and circuits utilised for the second stage alarm and automatic shut-down are to be independent of those required for the first stage alarm.

12.2 Thermal fluid heaters

12.2.1 Alarms and safeguards are indicated in 12.2.2 to 12.2.8 and Table 14.2.1.

12.2.2 The standby pumps for oil fuel and thermal fluid circulation are to start automatically when the discharge pressure from the working pump falls below a predetermined value. The standby pumps for thermal fluid circulation are to start before shut-off due to low thermal fluid pressure, see Table 14.2.1, is activated.

12.2.3 The following heater services are to be fitted with automatic controls so as to maintain steady state conditions throughout the operating range of the heater:

- Combustion system.
- Oil fuel supply temperature or viscosity (heavy oil only).
- Thermal fluid temperature.

12.2.4 Burner controls are to be arranged such that light-off is only possible at the minimum firing rate compatible with flame establishment. If ignition is set to occur at a fuel rich condition then the burner is to revert to the correct operating air/fuel ratio on establishment of a stable flame.

12.2.5 Arrangements are to be such that burner oil fuel valve(s) do not open:

- prior to completion of required warm up times for residual fuel oil; or
- when the power supply to the igniter has failed, as applicable; or
- until a pilot flame is established, as applicable; or
- prior to the completion of furnace purging, see 3.1.7.

12.2.6 Arrangements for flame failure detection are to be provided with self-monitoring capabilities which ensure that the flame detector is not erroneously indicating the presence of a flame. In the event of failure being detected by these self-monitoring capabilities:

- an alarm is to be activated;
- In the event of loss of flame detection capability for a burner;
- oil fuel to the burner is to be shut off automatically; and
- an alarm is to be activated.

12.2.7 Where established as necessary by 3.1.8, means are to be provided to prevent starting of the ignition sequence following multiple flame failures until completion of the identified lock-out period.

12.2.8 Following burner shut-down, the furnace is to be purged automatically for at least the required pre-purging time. In event of shut-down due to activation of a required safeguard, this purging is to be manually initiated.

Table 14.12.1 Thermal fluid heaters: Alarms and safeguards

Item	Alarm	Note
Expansion tank level*	Low	Oil fuel burners to be shut off automatically
Thermal fluid flow	Low	Oil fuel burners to be shut off automatically, see Note 5
Thermal fluid pressure	Low	Oil fuel burners to be shut off automatically
Thermal fluid outlet temperature*	1st stage high 2nd stage high	— Oil fuel burners to be shut off automatically, see 12.1.4
Combustion air pressure*	Low	Oil fuel burners to be shut off automatically in operation or not released during start-up, see Note 3. Purge sequence to be inhibited see 3.1.7
Oil fuel pressure*	Low	—
Oil fuel temperature or viscosity*	High and low	Heavy oil only
Oil fuel atomising steam/air pressure	Low	—
Burner flame*	Failure	Each burner to be monitored. Oil fuel to burner to be shut off automatically, see 3.1.9 to 3.1.10, and Note 3
Flame monitoring device(s)*	Failure	See 3.6.6 and Note 3
Igniter power supply*	Failure	Each igniter to be checked before oil fuel is supplied to burner(s), see 3.6.5 and Note 3
Forced draft fan*	Power failure	Oil fuel burners to be shut off automatically in operation or not released during start-up, see Note 3
Air register and dampers (including those in the uptake)*	Not fully open	Purge sequence to be inhibited, see 3.1.7
Control system*	Power failure	Oil fuel burners to be shut off automatically. Control using alternative arrangement is to remain available, see Pt 6, Ch 1,2.5.8
Uptake temperature	High	To monitor for soot fires. Oil fuel to the burner is to be shut off, see Notes 4 and 6

NOTES

1. Special consideration may be given to the requirements for oil-fired hot water heaters.
2. For heaters not supplying thermal oil for services essential for the safety or the operation of the ship at sea, only the items marked* are required.
3. These safeguards are to remain operative during automatic, manual and emergency operation.
4. Alarm and oil fuel shut-off is only required where exhaust gas economisers/boilers are fitted.
5. For exhaust gas economisers/boilers requiring thermal fluid forced circulation, the low flow alarm is to be fitted with provision to override the alarm if the exhaust gas economiser/boiler is to be operated in the dry condition. *See also* 6.2.5.
6. Alternatively, details of an appropriate fire detection system are to be submitted for consideration.

12.3 Inert gas generators

12.3.1 Alarms and safeguards are indicated in 12.3.2 and Table 14.12.2.

12.3.2 Inert gas generators are to be fitted with an automatic combustion control system in order to maintain steady state conditions throughout the operating range of the generator.

12.3.3 For the requirements of flue gas inert gas systems, see Ch 15,7.

12.4 Incinerators

12.4.1 Alarms and safeguards are indicated in 12.4.2, 12.4.3 and Table 14.12.3.

12.4.2 Where arrangements are provided to introduce solid waste into the furnace, these are to be such that there is no risk of a fire hazard.

12.4.3 The combustion temperature is to be controlled to ensure that all liquid and solid waste is efficiently burned without exceeding predetermined temperature limits.

12.5 Miscellaneous machinery

12.5.1 Alarms and safeguards are indicated in 12.5.2 to 12.5.6 and Table 14.12.4.

12.5.2 **Dual fuel systems.** Oil and gas dual-fired systems for boilers and engines are to be provided with indication to show which fuel is in use.

12.5.3 **Lifts.** For details of alarms and safeguards for lifts classed by LR, reference is to be made to LR's *Code for Lifting Appliances in a Marine Environment*.

Table 14.12.2 Inert gas generators: Alarms and safeguards

Item	Alarm	Note
Inert gas outlet temperature	High	Oil fuel burners to be shut off automatically
Combustion air pressure	Low	Oil fuel burners to be shut off automatically
Oil fuel pressure	Low	—
Oil fuel temperature or viscosity	High and low	Heavy oil only
Burner flame and ignition	Failure	Oil fuel to burner to be shut off automatically, see Note 1
Cooling water pressure or flow	Low	Oil fuel to burner to be shut off automatically
Cooling water temperature	High	—
Combustion space cooling water level (where continuous circulation is required)	High	Cooling water pump and oil fuel to burner are to be shut off automatically
Oil fuel supply	Insufficient	
Power supply to inert gas generator	Failure	Gas regulating valve is to be shut down automatically
Automatic control system power supply	Failure	
NOTES		
1. Combustion spaces are to be purged automatically before re-ignition takes place in the event of a flame-out on all burners.		
2. See also Chapter 15.		

12.5.4 Oil heaters. Oil fuel or lubricating oil heaters are to be fitted with a high temperature alarm which may be incorporated in the temperature control system. In addition to the temperature control system, an independent sensor with manual reset is to be fitted, which will automatically cut off the heating supply in the event of excessively high temperatures or loss of flow, except where the maximum temperature of the heating medium remains limited to a value below 220°C.

12.5.5 Oil tank electric heating. Oil fuel and lubricating oil tanks that are provided with electric heating elements are to be fitted with a high temperature alarm, which may be incorporated in the temperature control system, a low level alarm and an additional low level sensor to cut off the power supply at a level above that at which the heating element would be exposed.

12.5.6 Oil fuel tanks. Means are to be provided to eliminate the possibility of overflow from oil fuel service tanks into the machinery space and to safeguard against overflow of oil from oil fuel service tanks through the air pipe. See Chapter 13 regarding the termination of air pipes.

Table 14.12.3 Incinerators: Alarms and safeguards

Item	Alarm	Note
Oil fuel temperature or viscosity	High and low	Heavy oil and sludge
Oil fuel pressure	Low	—
Combustion air pressure	Low	Oil fuel and/or sludge to burners to be shut off automatically
Burner flame and ignition	Failure	Oil fuel and/or sludge to burners to be shut off automatically, see Note
Furnace temperature	High	Oil fuel and/or sludge to burners to be shut off automatically
Furnace temperature	Low	If applicable
Exhaust temperature	High	—
NOTE		
Combustion spaces are to be purged automatically before re-ignition takes place in the event of a flame-out on all burners.		

Part 5, Chapters 14, 15 and 18

Table 14.12.4 Miscellaneous machinery: Alarms and safeguards

Item	Alarm	Note
Stern tube lubricating oil tank level	Low	—
Stern tube bearing temperature (oil lubricated)	High	—
Coolant tanks level	Low	—
Oil fuel service tanks level	High and low	Where a common overflow tank is fitted, a high level alarm in the common overflow tank may be accepted
Oil fuel service tanks temperature	High	Where heating arrangements are fitted
Oil fuel settling tanks temperature	High	Where heating arrangements are fitted
Sludge tanks level	High	—
Feed water tanks level	Low	Service tank only
Purifier water seal broken	Fault	—
Purifier oil inlet temperature	High	—
Air compressor lubricating oil	Failure	Automatic shut-down
Air compressor discharge air temperature	High	—
Hydraulic control system pressure	Low	—
Pneumatic control system pressure	Low	—
Oil heater temperature	High	—
Control environmental conditions	Abnormal	See also Pt 6, Ch 1, 1.3.3

Part 5, Chapter 15

Piping Systems for Oil Tankers

Effective date 1 July, 2012

■ Section 1

General requirements

1.6 Cargo pump room

1.6.1 Control engineering systems are to be in accordance with the requirements of Pt 6, Ch 1.

Existing paragraphs 1.6.1 to 1.6.6 have been renumbered 1.6.2 to 1.6.7.

Part 5, Chapter 18

Integrated Propulsion Systems

Effective date 1 July, 2012

■ Section 3

Control arrangements

3.2 Alarm system

~~3.2.12 Arrangements should be made to enable alarm lights on the bridge to be dimmed as required.~~

Part 6, Chapter 1

Control Engineering Systems

Effective date 1 July, 2012

■ Section 1

General requirements

1.2 Plans

1.2.2 Where control, alarm and safety systems are intended for the machinery or equipment as defined in 1.2.3 the following are to be submitted:

- Description of operation with explanatory diagrams.
- Line diagrams of control circuits.
- List of monitored points.
- List of control points.
- ~~List of alarm points.~~ Details of alarms and warnings to be presented by the user interface, including:
 - (i) an approach to category assignments which is in accordance with the IMO *Code on Alerts and Indicators, 2009*; and
 - (ii) for alarms required by these Rules, the intended operator response and the message to be presented.
- Test schedules (for both works testing and sea trials) which should include methods of testing and test facilities provided, see 1.3.1.
- Failure Mode and Effects Analysis (FMEA) where required by other sections of the Rules.
- List of safety functions and details of any overrides, including consequences of use, see 2.4.9 and 2.6.9.

(Part only shown)

1.2.3 Plans for the control, alarm and safety systems of the following are to be submitted:

- Air compressors.
- Bilge and ballast systems.
- Cargo pumping systems for tankers.
- Cargo and ballast pumps in hazardous areas.
- Cargo tank, cargo hold, ballast tank and void space instrumentation where such arrangements are specified by other Sections of the Rules (e.g. water ingress detection, gas detection).

1.2.7 **Control station.** ~~Location and details of control stations are to be submitted, e.g. control panels and consoles.~~ Plans showing the location and details of control stations, e.g. control panels and consoles, location and details of controls and displays on each panel. Details of user interface specifications. A general arrangement plan of control rooms showing the position of consoles, handrails, operator area, lighting, door and window arrangements. Drawing of HVAC systems including vent arrangements.

~~1.2.9 **Approved system.** Where it is intended to employ a standard system which has been previously approved, plans are not required to be submitted, providing there have been no changes in the applicable Rule requirements. The building port, where applicable, and date of the previous approval is to be advised.~~

Existing paragraph 1.2.10 has been renumbered 1.2.9.

■ Section 2

Essential features for control, alarm and safety systems

2.1 General

2.1.1 Where it is proposed to install control, alarm and safety systems to the machinery and equipment defined in 1.2.3 the applicable features contained in this Section are to be incorporated in the system design.

2.2 Control stations for machinery

2.2.1 A system of alarm and warning displays and controls is to be provided which readily ensures identification of faults in the machinery and satisfactory supervision of related equipment by duty personnel. This may be provided at a main control station or, alternatively, at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.

2.2.3 Where operator interfaces are installed in the wheelhouse, illumination should not interfere with night vision. All illumination and lighting of instruments, keyboards and controls are to be adjustable to zero illumination, except for lighting for visual indication of alarms and the controls of dimmers, which are to remain readable.

Existing paragraphs 2.2.3 to 2.2.7 have been renumbered 2.2.4 to 2.2.8.

2.3 Alarm systems, general requirements

2.3.1 Where an alarm system, which will ~~provide warning of faults~~ alert relevant personnel to faults, abnormal situations and other conditions requiring attention in the machinery and the safety and control systems, required by this Chapter or other Sections of the Rules is to be installed, the requirements of 2.3.2 to ~~2.3.18~~ 2.3.20 are to be satisfied.

2.3.3 Alarms and warnings associated with machinery and equipment required to satisfy this sub-Section are to be categorised according to the urgency and type of response required by the crew, as described in the IMO *Code on Alerts and Indicators, 2009*. The assignment of a category to each alert is to be evaluated on the basis not only of the machinery or equipment being monitored, but also the complete installation. Categories not included in an alarm system may be omitted from the system design. Details of alternative alert management proposals supported with evidence of service experience may be submitted for consideration by LR.

2.3.4 Where the facility to provide messages in association with alarms and warnings exists, messages accompanying alarms and warnings are to describe the condition and indicate the intended response required by the crew.

Part 6, Chapter 1

~~2.3.3~~ 2.3.5 Where the facility to provide messages in association with alarms and warnings exists messages of different categories are to be clearly distinguishable from each other. Alarms associated with machinery, safety and control system faults are to be clearly distinguishable from other alarms (e.g., fire, general alarm).

~~2.3.4~~ 2.3.6 Where alarms are displayed as group alarms provision is to be made to identify individual alarms at the main control station (if fitted) or alternatively at subsidiary control stations.

~~2.3.5~~ 2.3.7 All alarms are to be both audible and visual. If arrangements are made to silence audible ~~alarms signals~~ they are not to extinguish visual ~~alarms indications~~.

~~2.3.6~~ 2.3.8 Acknowledgement of visual alarms is to be clearly indicated.

~~2.3.7~~ 2.3.9 Acknowledgement of alarms at positions outside a machinery space is not to silence the audible ~~alarm signal~~ or extinguish the visual ~~alarm indication~~ in that machinery space.

~~2.3.8~~ 2.3.10 If an alarm has been acknowledged and a second fault occurs prior to the first being rectified, audible ~~signals~~ and visual ~~alarms indications~~ are again to operate. Where alarms are displayed at a local panel adjacent to the machinery and with arrangements to provide a group or common fault alarm ~~at the main in the control room alarm display~~, then the occurrence of a second fault prior to the first alarm being rectified need only be displayed at the local panel, however, the group alarm is to be re-initiated. Unacknowledged alarms on monitors are to be distinguished by either flashing text or a flashing marker adjacent to the text. A change of colour will not in itself be sufficient to distinguish between acknowledged and unacknowledged alarms.

Existing paragraphs 2.3.9 to 2.3.14 have been renumbered 2.3.11 to 2.3.16.

~~2.3.15~~ 2.3.17 Disconnection or manual overriding of any part of the alarm system ~~should~~ ~~is~~ to be clearly indicated.

~~2.3.16~~ 2.3.18 When alarm systems are provided with means to adjust their set point, the arrangements are to be such that the final settings can be readily identified.

~~2.3.17~~ 2.3.19 Where monitors are provided at the station in control and, if fitted, in the duty engineer's accommodation, they are to provide immediate display of new alarm information regardless of the information display page currently selected. This may be achieved by provision of a dedicated alarm monitor, a dedicated area of screen for alarms or other suitable means.

~~2.3.18~~ 2.3.20 Where practicable, alarms displayed on monitors are to be displayed in the order in which they occur. Alarms requiring ~~manual~~ shutdown or slowdown action are to be given visual prominence.

2.9 Fixed water-based local application fire-fighting systems

2.9.5 A control panel is to be provided for managing actions such as opening of valves, starting of pumps and ~~sounding initiation~~ of alarms and warnings and processing information from detectors. This panel is to be independent of the fire detection control unit required by 2.8.

2.9.6 Alarms are to be initiated upon activation of a system and are to indicate the specific zone activated at the control panel. Alarms are to be provided in each protected space, at an attended machinery control station and in the wheelhouse. The audible alarm signal is to be distinguishable from other safety system ~~alarms signals~~.

2.10 Programmable electronic systems – General requirements

~~2.10.16 User interfaces are to enable timely access to desired information or control of functions. A system overview is to be readily available.~~

~~2.10.17 The keyboard is to be divided logically into functional areas. Alphanumeric, paging and specific system keys are to be grouped separately.~~

~~2.10.18 Where a function may be accessed from more than one interface, the arrangement of displays and controls is to be consistent.~~

~~2.10.19 The size, colour and density of information displayed to the operator are to be such that information may be easily read from the normal operator position under all operational lighting conditions.~~

~~2.10.20~~ 2.10.16 Display units are to comply with the requirements of an acceptable National or International Standard, e.g. IEC 60950:1999 ~~2005~~, *Safety of information technology equipment*, in respect of emission of ionising radiation.

~~2.10.21 The symbols used in mimic diagrams for the services listed in Pt 6, Ch 2, 1.5.1 are to be consistent across all displays.~~

Existing paragraphs 2.10.22 to 2.10.25 have been renumbered 2.10.17 to 2.10.20.

Section 3 Ergonomics of control stations

3.1 Objectives

3.1.1 In order to take account of operator tasks at control stations, enhance usability and reduce human error, the layout arrangements are to comply with the requirements set out in 3.2.

3.1.2 In order to establish a working environment that has minimum distractions, is sufficiently comfortable, helps maintain vigilance and maximises communication amongst operators at main control stations, the requirements of 3.3 are to be complied with.

3.1.3 The requirements of 3.4 to 3.6 apply to operator interfaces for essential engineering systems located either locally, remotely or within the main control room. The requirements are intended to enhance the usability of systems and equipment, reduce human error, enhance situational awareness and support safe and effective monitoring and control under normal and abnormal modes of operation.

3.2 Control station layout

3.2.1 Control stations are to provide sufficient space and access for the intended number of operators in the expected operating conditions.

3.2.2 Local control stations are to be positioned to minimise the risk of harm to the operator.

3.2.3 Controls, displays and indicators are to be both logically and physically grouped, according to their function.

3.2.4 Where a function may be accessed from more than one interface, the arrangement of displays and controls is to be consistent.

3.2.5 Frequently used controls and displays are to be within easy reach and visible to the operator from the normal working position.

3.2.6 Controls and displays used infrequently and which may be used in an emergency are to be clearly identifiable, clearly visible, easily accessible and positioned to allow safe operability.

3.2.7 The relationship of a control with a display is to be immediately apparent.

3.2.8 The relationship of controls and displays with the equipment under control is to be immediately apparent.

3.2.9 There is to be adequate spacing between controls and between controls and obstructions.

3.2.10 Controls and their associated displays are to be located such that the information on the displays can be easily read during the operation of the controls.

3.2.11 Indicators related to controls are to be visible during their operation.

3.2.12 Instruments are to face the operator's intended working position.

3.3 Physical environment

3.3.1 Control stations are to be positioned, as far as practicable, away from, or insulated against, sources of structurally transmitted noise, such as ventilation fans, engine intake fans and other noise sources.

3.3.2 In general, noise levels are to comply with IMO Res. A.468(XII) *Code on Noise Levels on Board Ships*, and take into account IMO Res. A.343(IX), *Recommendation on Methods of Measuring Noise Levels at Listening Posts*.

3.3.3 Where provided, the heating, ventilation and air conditioning system is to be capable of maintaining the temperature between 18°C and 27°C.

3.3.4 The flow of air from heating or air conditioning systems is not to be guided directly to the operator, or means are to be provided to adjust the direction of airflow from those systems.

3.3.5 Lighting is to be located to avoid glare from working and display surfaces, and is to be flicker-free. Surfaces are to have a non-reflective or matt finish.

3.3.6 Placement of controls, displays and indicators are to consider the position of light sources relative to the operator, with respect to reflections and evenness of lighting.

3.3.7 Where a transparent cover is fitted over a control, display or indicator, it is to be designed to minimise reflections.

3.3.8 The level of lighting is to be sufficient to enable operation of user interfaces. Lighting levels in accordance with Table 1.3.1 will be considered to satisfy this requirement.

Table 1.3.1 Specific lighting levels

Work area	Ideal Lux	Minimum Lux
General Lighting	540	220
Control room consoles (front)	540	320
Control room consoles (rear)	325	110
Local operating panels	540	320
Remote operating panels	540	320

3.3.9 Chairs provided for use at control stations are to be adjustable to allow for varying heights of operators.

3.3.10 Physical hazards, e.g., sharp edges, protuberances and trip hazards, are to be avoided.

3.3.11 Sufficient handrails or equivalent are to be fitted to enable operators to move and stand safely in rough seas.

3.3.12 Work surfaces are to be capable of withstanding oils and solvents common to ships and are to be easy to clean.

3.4 Operator interface

3.4.1 The design of the operator interface is to permit the satisfactory monitoring, control and supervision of the machinery and equipment.

3.4.2 Information is to be presented to the operator consistently, both within and between different interfaces, see 3.6.2 to 3.6.4.

3.4.3 The response of the machinery and equipment to operator input is to be consistent between interfaces for the same function.

3.4.4 Visual, audible or mechanical feedback is to be provided to indicate that operator input has been acknowledged.

3.4.5 Functions requested by the operator are to be confirmed by the displays on completion.

3.4.6 Indications and documentation are to be in English or the language of the crew.

3.5 Controls

3.5.1 Operator inputs are to be checked for errors, for example, out of range data or incorrect actions, and the operator is to be alerted when they occur.

3.5.2 Means are to be provided to correct wrong inputs or commands rapidly and safely.

3.5.3 Assistance is to be provided to the operator to recover from operator errors, for example, through advisory screens where the automation system has this facility.

3.5.4 Operator confirmation is to be provided for any control action that could affect the safety of the ship, i.e., they should not rely on single keystrokes.

3.5.5 The purpose of each control is to be clearly indicated. Where standard symbols have been internationally adopted, they should be used.

3.5.6 The settings of mechanical controls are to be immediately evident.

3.5.7 The means of operation of mechanical controls is to be consistent with expectations.

3.5.8 Controls or combined controls and indicators are to be distinguishable from indicators.

3.5.9 Where control is provided by touch screens, the soft keys are to be of a sufficient size for operation in areas where vibration occurs or gloves are likely to be worn.

3.5.10 Where virtual keypads/keyboards or dialogue boxes are used on touch screens, they are not to obscure status or alarm areas of the display.

3.5.11 Keyboards are to be divided logically into functional areas. Alphanumeric, paging and specific system keys are to be grouped separately.

3.6 Displays

3.6.1 The displays and indicators are to present the operator with clear, timely and relevant information.

3.6.2 Graphical symbols and colour coding are to be consistent. The graphical symbols of display functions are to be in accordance with a recognised International Standard, for example, ISO 14617, *Graphical symbols for diagrams*. Colour coding of functions and signals is to be in accordance with a recognised International Standard, for example, ISO 2412:1982, *Shipbuilding – Colours of indicator lights*.

3.6.3 The symbols used in mimic diagrams for the services listed in Pt 6, Ch 2, 1.5.1 are to be consistent across all displays.

3.6.4 The display of information is to be consistent with respect to screen layout and arrangement of information.

3.6.5 Flashing of information is to be reserved for unacknowledged alerts or transient states, for example, valve moving.

3.6.6 The functions supported by a display are to be clearly indicated. For displays that can support multiple functions, it is to be possible to select the display associated with the primary function or an overview by a simple operator action.

3.6.7 The operating mode of the machinery and equipment is to be clearly indicated.

3.6.8 In general, indications provided by instrumentation which are displayed digitally are not to change more frequently than twice per second.

3.6.9 To indicate an increasing value in a single direction, on a fixed circular scale, the pointer is to move clockwise. If the pointer is fixed, the scale is to move anticlockwise to indicate an increase in value.

3.6.10 To indicate an increasing value on a horizontal linear scale, the pointer is to move from left to right. On a vertical linear scale, the pointer is to move upwards to indicate an increase in value.

3.6.11 The pointer is not to obscure the numbers on the scale.

3.6.12 Alphanumeric data, text, symbols and other graphical information is to be readable from relevant operator positions under lighting conditions, as specified in 3.3.8. Character height in millimetres is to be not less than three and a half times the reading distance in metres and character width is to be 0,7 times the character height.

3.6.13 A simple sans-serif character font is to be used in displays. In descriptive text, lower case letters are to be used, where appropriate, as opposed to capitals, to improve readability.

3.6.14 Where information related to the safe operation of machinery and equipment is provided, it is to be continuously available to the operator.

3.6.15 Failures are to be indicated in a clear and unambiguous manner. Sufficient information is to be provided for the operator to identify the cause of the failure.

Existing Section 3 has been deleted.

Section 4 Unattended machinery space(s) – UMS notation

4.2 Alarm system for machinery

4.2.3 The engineers' alarm required by 2.2.3 is to be activated automatically in the event that a machinery alarm or warning has not been acknowledged in the space within a predetermined time.

4.2.5 Group alarms may be arranged on the bridge to indicate machinery faults, but alarms associated with faults requiring speed or power reduction or the automatic shut-down of propulsion machinery are to be identified by separate group alarms or by individual alarm parameters alarms.

Part 6, Chapter 2 Electrical Engineering

Effective date 1 July, 2012

Section 1 General requirements

1.2 Plans required for design review

1.2.1 ~~At least three copies of the plans and particulars in 1.2.2 to 1.2.13 are to be submitted for consideration. Single copies only are required of plans in 1.2.16 to 1.2.19. Additional copies are to be submitted when requested. The plans and particulars in 1.2.2 to 1.2.17 are to be submitted for design review.~~

1.2.3 A description of operation of the main and emergency electrical power systems.

1.2.4 An earthing philosophy document that defines the basic approach to be taken for earthing the electrical power systems and all electrical loads.

Existing paragraphs 1.2.3 to 1.2.4 have been renumbered 1.2.5 to 1.2.6.

1.2.7 Where required by 8.1.1, the hazards resulting from electric arcs within electrical equipment and their consequences for personnel are to be identified, and at least the following supporting evidence is to be submitted:

- (a) system design;
- (b) operating philosophies, e.g., manual or automatic control, local or remote operation;
- (c) general arrangement plans for switchboards, section boards and distribution boards, see also 1.2.19;
- (d) general arrangement plans for the space in which the electrical equipment to be assessed are located showing:
 - (i) access to adjacent spaces;
 - (ii) the location of the electrical equipment;
 - (iii) ventilation arrangements for air conditioning

- and/or the extraction of smoke, gas and vapours resulting from electric arcs; and
- (iv) positions within the space in which the electrical equipment is located where personnel will be performing tasks, e.g., switching, equipment maintenance, instrument observation or cleaning, or where personnel could reasonably be expected to enter;
- (e) calculations in accordance with 8.3;
- (f) system operating procedures; and
- (g) details of defined additional safety measures to be taken during activities.

~~1.2.8~~ 1.2.11 Details of electrically operated fire, ship, crew and passenger emergency safety systems which are to include typical single line diagrams and arrangements, showing main vertical and, where applicable, horizontal fire zones, spaces along the ship bottom that are not fitted with a double bottom and the location of equipment and cable routes, including identification of relevant high fire risk areas, to be employed for:

- (a) emergency lighting;
- (b) accommodation fire detection, alarm and extinction systems;
- (c) fixed water-based local application fire-fighting systems;
- (d) public address system;
- (e) general emergency alarm;
- (f) watertight doors, bow, stern and shell doors and other electrically operated closing appliances; and
- (g) low location lighting.

NOTE

A general arrangement plan of the complete ship showing the main vertical fire zones, spaces along the ship bottom that are not fitted with a double bottom and the location of equipment and cable routes, including identification of relevant high fire risk areas, for the above systems, is to be made available for the use of the Surveyor on board.

Existing paragraphs 1.2.5 to 1.2.14 have been renumbered as 1.2.8 to 1.2.17.

1.3 Plans required for supporting evidence

1.3.1 The plans and particulars in 1.3.2 to 1.3.5 are to be submitted as supporting evidence.

1.3.2 Plans for all cables that pass through atria or equivalent spaces, and for vertical runs in trunks or other restricted spaces. The information supplied is to show compliance with 10.8.10.

Existing paragraph 1.2.16 has been renumbered 1.3.3.

1.3.4 Arrangement plans of main and emergency switchboards, and section boards, and documentation that demonstrates that creepage and clearance distances are in accordance with 7.5.

1.3.5 Schedule of normal and emergency operating loads on the system estimated for the different operating conditions expected. The following details are to be provided to meet this requirement:

- (a) a description of the expected operating profiles (e.g., the number of generating sets connected when manoeuvring at sea, etc.), including that required by Pt 5, Ch 2, 1.1.1; and
- (b) a schedule of the normal and emergency operating loads, which is to state the kilowatt rating of each load and a load factor between 0 and 1 that reflects:
 - (i) the duty cycle of the load; and
 - (ii) the proportion of its maximum rating at which the load is expected to operate.

1.3.6 In order to establish compliance with the requirements of 1.7.3, when requested, evidence is to be submitted to demonstrate the suitability of electrical equipment for its intended purpose in the conditions in which it is expected to operate.

Existing paragraph 1.2.20 has been renumbered 1.3.7.

Existing sub-Sections 1.3 to 1.18 are to be renumbered 1.4 to 1.19.

1.6 Definitions

1.6.16 An ‘electric arc’ is an electrical discharge or a short-circuit through ionised air caused by isolation or insulation integrity failure.

1.6.17 ‘Incident energy’ is the amount of energy impressed on a surface, a certain distance from the source, generated during an electric arc event.

1.12 Earthing of non-current carrying parts

1.12.11 The connection of the earthing conductor to the hull of the ship is to be made in an accessible position, and is to be secured by a screw or stud of a diameter appropriate for the size of earthing conductor, but not less than 6 mm, which is to be used for this purpose only. Bright metallic surfaces at the contact areas are to be ensured immediately before the nut or screw is tightened and, where necessary, the joint is to be protected against electrolytic corrosion. The connection is to remain unpainted.

1.13 Bonding for the control of static electricity

1.13.2 Where bonding straps are required for the control of static electricity, they are to be robust, that is, having a cross-sectional area of about at least 10 mm², and are to comply with 1.12.7 and 1.12.11.

1.14 Alarms

1.14.1 Where alarms are required by this Chapter they are to be arranged in accordance with Ch 1, 2.3. Sound signal equipment, fire and general alarm bells are not required to be supplemented by visual alarm indications, except in areas having high levels of background noise, such as machinery spaces.

1.14.2 The alarms in this Chapter are additional to those required by Chapter 1. They may however form part of the alarm system that is required by Chapter 1.

1.14.3 Cables for emergency alarms and their power sources are to be in accordance with 1.16.

1.14.4 Electrical equipment and cables for emergency alarms are to be so arranged that the loss of alarms in any one area due to localised fire, collision, flooding or similar damage is minimised, see 1.16 and 1.17.

1.14.5 Electric system: Alarms and safeguards are indicated in Table 2.1.2.

Table 2.1.2 Electric system: Alarms and safeguards

Item	Alarm	Note
Busbar voltage	High and low	–
Busbar frequency	Low	–
Operation of load shedding	Warning	–
Generator cooling air temperature	High	For closed air circuit water-cooled machines

Existing sub-Sections 1.14 has been renumbered 1.15.

Existing Table 2.1.2 has been renumbered Table 2.1.3.

1.16 Operation under fire conditions

1.16.1 As a minimum, the following emergency services and their emergency power supplies are required to be capable of being operated under fire conditions:

- Control and power systems to power-operated fire doors and status indication for all fire doors.
- Control and power systems to power-operated watertight doors and their status indication.
- Emergency lighting.
- Fire and general emergency alarms.
- Fire detection systems.

- Fire-extinguishing systems and fire-extinguishing media release alarms.
- Fire safety stops, see also 16.6.
- Low location lighting, see also 17.4.3.
- Public address systems.
- Emergency fire pump.

Section 5

Supply and distribution

5.4 Insulated distribution systems

5.4.1 A device(s) is to be installed for every insulated distribution system, whether primary or secondary, for power, heating and lighting circuits, to continuously monitor the insulation level to earth and to operate an alarm in the engine control room, or equivalent attended position, in the event of an abnormally low level of insulation resistance, see also Ch 1.4.2.

Section 7

Switchgear and control gear assemblies

7.1 General requirements

7.1.1 Switchgear and control gear assemblies and their components are to comply with one of the following standards amended where necessary for ambient temperature and other environmental conditions:

- IEC 60439-1: *Low voltage switchgear and control gear assemblies*;
- IEC 62271-200: *AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*;
- IEC 60466: *AC insulated-enclosed switchgear for rated voltages above 1 kV and up to and including 38 kV*;
- IEC 60255: *Electrical relays*;
- acceptable and relevant National Standard.

In addition, the requirements of 7.2 to 7.19 are to be complied with.

7.5 Creepage and clearance distances

7.5.3 Creepage distances cannot be accurately specified as they depend upon the insulating material, dust deposits, humidity, etc. They are to be not less than the clearance distances given in Table 2.7.1, or less than 16 mm per 1000 V (rated voltage), whichever is the greater.

7.5.3 Switchgear and control gear assemblies for rated voltages up to and including 1 kV are to have creepage distances in accordance with IEC 60092-302, *Electrical installations in ships – Part 302: Low voltage switchgear and control gear assemblies*, and Table 2.7.2.

7.5.4 For switchgear and control gear assemblies for rated voltages up to and including 1 kV, a minimum creepage

distance of 16 mm is permitted for type tested assemblies. The type tests are to include verification of the degree of protection, insulation material group and creepage and clearance distances in accordance with IEC 61439-1, *Low voltage switchgear and control gear assemblies – Part 1: General Rules*.

7.5.5 Switchgear and control gear assemblies for rated voltages above 1 kV are to have creepage distances in accordance with IEC 60092-503, *Electrical installations in ships – Part 503: Special features – AC supply systems with voltages in the range of above 1 kV up to and including 15 kV*. In the absence of alternative proposals including supporting design rationale, the distances stated in Table 2.7.2 are to be used, see also 1.3.4.

7.5.6 For switchgear and control gear assemblies for rated voltages up to and including 1 kV, the type testing stated in Table 2.7.1 is to include verification of the degree of protection in accordance with a relevant International or National Standard.

Table 2.7.1 Minimum clearance distances

Rated Voltage V	Minimum clearance (mm) between phases and earth		Minimum clearance (mm) between phases
	Earthed neutral	Insulated neutral	
≤660	16	19	19
1000	25	25	25
3600	55	55	55
7200	70	100	100
12000	85	140	140
15000	100	165	165

Table 2.7.1 Minimum clearance distances

Nominal Voltage V	Minimum clearance (mm)			
	Main switchboards		Other switchgear and control gear	
	Type tested assemblies	Non-type tested assemblies	Type tested assemblies	Non-type tested assemblies
≤250	8	15	8	15
<250 to ≤ 690	8	20	8	20
>690 to 1000	8	25	8	25
<1,100	14	14	14	14
<3,300	32	55	26	55
<6,600	60	90	50	90
<11,000	100	120	80	120
<15,000	100	160	100	160

NOTE
A minimum clearance distance of 25 mm is required for busbars and other bare conductors in main switchboards.

Table 2.7.2 Minimum creepage distances

Nominal Voltage V	Minimum creepage distance (mm)	
	Main switchboards	Other switchgear and control gear
≤250	20	20
>250 to ≤ 690	25	25
>690 to 1000	35	35
<3,300	48	35
<6,600	90	70
<11,000	150	120
≤15,000	150	120

NOTE
A minimum creepage distance of 16 mm is permitted for type tested assemblies for rated voltages up to and including 1 kV, see 7.5.4.

7.8 Earthing of high-voltage switchboards

7.8.2 Protective shutters associated with withdrawable parts are to be clearly marked, e.g., by colour coding, to indicate the incoming and outgoing circuits and bus tie connections.

Section 8

Protection from electric arc hazards within electrical equipment

8.1 General

8.1.1 An assessment is to be carried out in accordance with 8.2.1 for all electrical equipment within which an arcing fault could occur, such as:

- harmonic filters;
- motor starter panels;
- semiconductor converters;
- switchboards, section boards and distribution boards; or
- transformers.

8.2 Hazard identification and assessment

8.2.1 An assessment is to be carried out to identify the hazards and their consequences for personnel resulting from electric arcs within the electrical equipment identified in 8.1.1. The purpose of the assessment is to demonstrate that the design incorporates adequate measures to reduce the risk of injury to personnel should an arcing fault occur within the electrical equipment, and that this will help to ensure both personnel and ship safety.

Details of the following are to be submitted:

- each task to be performed, e.g., switching, equipment maintenance, instrument observation or cleaning;
- the hazards to personnel that could result from an electric arc occurring during each task, and the hazards to personnel that could result from the electric arc;
- the methods to be used to help to prevent electric arcs; and
- the methods to be used to protect personnel from hazards resulting from electric arcs within electrical equipment.

8.3 Calculations to be submitted

8.3.1 The following calculations are to be conducted and used in the hazard identification and assessment:

- calculations of the maximum current that would flow through an electric arc between each conductor and its adjacent conductor, and between each conductor and the exposed conductive parts of the enclosure, in the case of an arcing fault;
- the maximum incident energy at the intended working distance in the case of an arcing fault; and
- the distance from each conductor at which the incident energy would be 5 Joules (1,2 calories) per centimetre squared in the case of an arcing fault when the enclosure door is open.

These calculations may be made in accordance with a relevant Standard acceptable to LR, for example, IEEE Standard 1584, *IEEE Guide for Performing Arc-Flash Hazard Calculations*.

8.4 Testing and trials

8.4.1 It is to be demonstrated that, where provided, arrangements to detect arcing faults function correctly.

Section 9

Rotating machines

8.4.9.1 General requirements

~~8.4.9~~ 9.1.9 AC Propulsion motors, and generators and motors for electrical propulsion systems, that form part of are to have at least one embedded temperature detector (ETD) in each phase of the machine winding in locations which may be subjected to the highest temperature. Where there are two coil sides per slot the ETD's are to be located between the insulated coil sides in the slot, see ~~15.1.3~~ 16.1.5.

Existing Section 9 has been renumbered Section 10.

Section 10

Electric cables and busbar trunking systems (busways)

~~10.16~~ 11.16 Joints and branch circuits in cable systems

~~10.16.1~~ 11.16.1 If a joint is necessary it is to be carried out so that all conductors are adequately secured, insulated and protected from atmospheric action. The flame retardant properties or fire resisting properties of the cable are to be retained, the continuity of metallic sheath, braid or armour is to be maintained and the current carrying capacity of the cable is not to be impaired.

Existing Section 11 has been renumbered Section 12.

Existing Section 12 has been renumbered Section 13.

Section 13

Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts

Existing sub-Sections 13.1 to 13.4 have been renumbered 14.1 to 14.4.

~~13.5~~ 14.5 Hazardous zones and spaces

~~13.5.7~~ 14.5.7 The following zones or spaces are regarded as hazardous, **zone 1**:

- the interiors of spaces containing dangerous goods as defined by ~~13.5.5(d)~~ 14.5.5(d);
- unventilated spaces separated by a single bulkhead or deck from a cargo defined by ~~13.5.5(a)~~ 14.5.5(a);

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- (c) ventilated spaces containing pipework or equipment defined by ~~13.5.5~~ 14.5.5(b) and (e);
- (d) zones within a 1,5 m radius of ventilation outlets, hatches or doorways or other openings into spaces defined by (a), (b) or (c), or within 1,5 m of the ventilation outlets of spaces regarded by ~~13.7~~ 14.7 as open areas and which contain the pipework or equipment defined by ~~13.5.5~~ 14.5.5(b) or (e). Where the hazard results from flammable gas or vapour having a density relative to that of air of more than 0,75, the hazardous zone is considered to extend vertically downward to solid deck, or for a distance of 9 m, whichever is the lesser;
- (e) zones on open deck, or semi-enclosed spaces on open deck, within 3 m of the ventilation outlets of cargo tanks defined in 14.5.5(a), which permit the flow of small volumes of vapour or gas mixtures caused by thermal variation;
- ~~(e)~~ (f) zones within a 1,5 m radius of flanged joints, or glands or other openings defined by ~~13.5.5~~ 14.5.5(b); in the case of gas or vapour having a relative density of more than 0,75, the hazardous zone is considered to extend vertically downwards as described under (d);
- ~~(f)~~ (g) zones within a 1,5 m radius of flanged joints, or glands or other openings defined by ~~13.5.5~~ 14.5.5(e) and (f);
- ~~(g)~~ (h) zones within a 1,5 m radius of bunds or barriers intended to contain spillage of liquids defined by ~~13.5.5~~ 14.5.5(a);
- ~~(h)~~ (i) zones on open deck within a 1,5 m radius of any opening into a space defined by (a) or (b); and
- ~~(i)~~ (k) enclosed or semi-enclosed spaces with direct opening into a **zone 1** hazardous location.

~~13.5.8~~ 14.5.8 The following zones or spaces are regarded as hazardous, **zone 2**:

- (a) ventilated spaces separated by a single bulkhead or deck from a **zone 0** space;
- (b) zones on open deck extending 1,5 m beyond those defined by ~~13.5.7~~ 14.5.7(d), (e), (f), (g) or (h);
- (c) zones on open deck extending 2 m beyond those defined by 14.5.7(e);
- ~~(e)~~ (d) zones within a 1,5 m radius of ventilation inlets serving spaces defined by ~~13.5.7~~ 14.5.7(a) or (c); and
- ~~(d)~~ (e) enclosed or semi-enclosed spaces with direct opening into a **zone 2** hazardous location.

Existing sub-Sections 13.6 to 13.8 have been renumbered 14.6 to 14.8.

~~13.9~~ 14.9 Cable and cable installation

~~13.9.1~~ Electric cables are not to be installed in hazardous zones or spaces, except when forming part of an intrinsically safe circuit or where specifically permitted elsewhere in this Section.

Existing paragraphs 13.9.2 to 13.9.8 have been renumbered 14.9.1 to 14.9.7.

Existing sub-Sections 13.10 to 13.13 have been renumbered 14.10 to 14.13.

~~13.14~~ 14.14

Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk

~~13.14.6~~ Cables joints in cargo spaces are to be avoided where possible. Where joints are unavoidable, they are to be enclosed in metal clad or high impact strength plastic junction boxes of a type acceptable for **zone 1** or a hazardous area as defined in 13.5.3 or heat shrink or encapsulated crimp sleeve cable joints.

Existing paragraph 13.14.7 has been renumbered 14.14.6.

Section 14 15

Navigation and manoeuvring systems

15.5 Transverse thrust units

15.5.1 Where transverse thrust units are remotely controlled, means are to be provided at the remote control station to stop the propulsion unit.

15.5.2 Transverse thrust units are to be provided with indications of direction and magnitude of thrust and propeller pitch at each station from which it is possible to control justify the propeller pitch.

Existing paragraphs 14.5 and 14.6 are to be re-numbered 15.6 and 15.7.

Section 16 17

Fire safety systems

~~16.1~~ 17.1 Fire detection and alarm systems

17.1.1 Fire detection and alarm systems are to be in accordance with Chapter 9 of the *Fire Safety Systems Code (FSS Code)* and 17.1.2 to 17.1.18.

Existing paragraphs 16.1.1 to 16.1.11 have been renumbered as 17.1.2 to 17.1.12.

~~16.1.12~~ In passenger ships, detectors fitted in cabins, when activated, are also to be capable of emitting, or cause to be emitted, an audible alarm within the space where they are located.

~~16.1.19~~ Where it is intended that detectors be installed in external locations, e.g. cabin balconies, in addition to meeting the requirements for an environmental category suitable for open decks, (see Ch 1,2.8.8), they are also to be tested for sun irradiation and ultraviolet exposure with satisfactory results.

Section 17 18

Crew and passenger emergency safety systems

17.2 18.2 General emergency alarm system

~~17.2.1~~ 18.2.1 An electrically operated bell or klaxon or air-operated whistle with independent air supply or other equivalent warning system installed in addition to the ship's whistle or siren for sounding the general emergency alarm signal is to comply with the *International Life-Saving Appliances (LSA) Code* and with the requirements of this Section, see also ~~1.13~~ 1.14 and ~~1.15~~ 1.16.

Existing Section 18 has been renumbered 19.

Existing Section 19 has been renumbered 20.

Section 20 21

Testing and trials

Existing sub-Section 20.1 has been renumbered 21.1.

20.2 21.2 Trials

~~20.2.4~~ 21.2.4 It is to be demonstrated that the Rules have been complied with in respect of:

- (a) satisfactory performance of each generator throughout a run at full rated load;
- (b) temperature of joint, connections, circuit-breakers and fuses;
- (c) the operation of engine governors, synchronising devices, overspeed trips, reverse-current, reverse-power and over-current trips and other safety devices;
- (d) voltage regulation of every generator when full rated load is suddenly thrown off and when starting the largest motor connected to the system;
- (e) voltage drop at the worst case condition;
- (f) harmonic distortion of the voltage waveform, where declared;
- (g) satisfactory parallel operation, and kW and KVA load sharing of all generators capable of being operated in parallel at all loads up to normal working load;
- (h) all essential and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory;
- (j) propulsion equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction. The equipment is to have sufficient power for going astern to secure proper control of the ship in all normal circumstances. In passenger ships the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manoeuvring conditions, and so bring the ship to rest from maximum ahead service speed, is to be demonstrated at the sea trial; and
- (k) operation of power management for electric propulsion.

~~20.2.5~~ 21.2.5 Where necessary, measurements are to be taken as part of the trials specified in 20.2.4(c), (d), (e) and (f) to verify that the installation will provide a quality of power supply in accordance with the values listed in 1.7. Measurements are to be taken as part of the trials specified in 21.2.4(c), (d), (e) and (f) to verify that the installation will provide a quality of power supply in accordance with the values listed in 1.7.

21.2.6 Satisfactory load management in accordance with 6.9 is to be demonstrated. The demonstration is to include verification that the requirements of 1.7 will be met following disconnection of a generator under all defined operating profiles as agreed with the operators.

Existing paragraphs 20.2.6 to 20.2.7 have been renumbered 21.2.7 to 21.2.8.

Existing Section 21 have been renumbered Section 22.

Part 7, Chapter 9

Navigational Arrangements and Integrated Bridge Systems

Effective date 1 July, 2012

■ Section 1 General requirements

1.3 Definitions

1.3.1 The following definitions are applicable to these Rules:

- (a) **Workstation:**
A position at which one or several tasks, constituting a particular activity, is carried out.
- (b) **Navigation workstation:**
A workstation at which the navigator may carry out all tasks relevant for deciding, executing and maintaining course and speed in relation to waters and traffic. The instrumentation and controls at the navigation workstation should allow the navigator to:
- analyse the traffic situation;
 - monitor position, course, track, speed, time, propeller revolutions and pitch, rudder angle, depth of water, rate of turn, and wind speed and direction;
 - alter course and speed;
 - effect internal and external communications;
 - give and receive sound signals;
 - control navigational lights;
 - monitor and acknowledge navigational alarms and warnings;
 - confirm his well-being and watch-keeping awareness; and
 - record navigational data.

■ Section 2 Physical conditions

2.2 Environment

2.2.7 The noise level on the bridge is not to interfere with verbal communication, mask audible **alarms** **alarm signals**, or be uncomfortable to bridge personnel. In this respect, the ambient noise level in the wheelhouse in good weather is not to exceed 65 dB(A).

2.3 Lighting

2.3.2 All illumination and lighting of instruments, keyboards and controls are to be adjustable down to zero, except the lighting of **alarm** **and warning** indicators and the controls of dimmers which are to remain readable.

2.3.11 Means are to be provided to test alarm and **other** indicator lamps.

■ Section 3 Workstations

3.1 Navigation workstation

3.1.6 At least two different automatic position-fixing systems giving a continuous display of latitude and longitude are to be provided **in the interests of redundancy and diversity**. One of these is to be GPS or equivalent. ~~The other is to be Loran C or equivalent, depending on the area of operation.~~ The other is to be a system providing similar global coverage such as GLONASS, where available. When a second GPS receiver is installed to satisfy this requirement, at least one of the receivers is to be provided with differential correction functionality (DGPS) and the receivers are to be arranged to operate independently as far as is practicable.

■ Section 5 Integrated Bridge Navigation System – IBS notation

5.2 General requirements

5.2.5 The design features for computer hardware, local area networks and software required by Pt 6, Ch 1, 2.10, 2.11, 2.13 and 2.14 respectively are to be complied with. **Alarms and warnings** associated with hardware and data communication are to be incorporated in the centralised alarm system required by 4.1.

5.3 Equipment

5.3.8 The centralised alarm system and the watch safety system required by 4.1 and 4.2 respectively are to be incorporated as functions of the integrated bridge system and are to be presented to the navigating officer via the conning display. The presentation and display of **alarms and warnings** is not to mask, obscure or degrade essential information displayed to aid navigational functions and maintain awareness of the navigational information, see also 5.5.

5.4 Operator interface

5.4.11 Interfaces are to incorporate the capability for operators readily to decline or override automatic ship control functions critical to safe operation. See Pt 6, Ch 1, 1.2.2 regarding submission of information on safety functions and overrides.

Existing paragraphs 5.4.11 to 5.4.15 have been renumbered 5.4.12 to 5.4.16.

5.5 Alarm management

5.5.2 In general, the alarm system is to be in accordance with Pt 6, Ch 1,2.3, A.1021(26) *Code on Alerts and Indicators, 2009* and MSC.302(87) *Performance Standards for Bridge Alert Management*.

5.5.3 Alarm management on priority and functional levels is to be provided within the integrated bridge system, ~~including distribution and recording of alarms, as required.~~ ~~Priorities are to be~~ Alarms and other alerts are to be prioritised according to the urgency and type of response required by the bridge team, as follows:

- (a) **Emergency alarms** – alarms which indicate that immediate danger to human life, or to the ship and its machinery exists and that immediate action must be taken.
- (b) ~~Distress, urgency and safety alarms~~ **Alarms** – conditions requiring immediate attention and action by the bridge team:
 - to avoid any kind of hazardous situation and to maintain the safe operation of the ship, including escalation of unacknowledged warnings; or
 - ~~alarms alerts~~ which indicate that a caller is in distress or has an urgent message to transmit.
- (c) ~~Primary alarms~~ – ~~alarms which indicate a condition that requires prompt attention to prevent an emergency condition.~~

Warnings – conditions or situations which require immediate attention for precautionary reasons, to make the bridge team aware of conditions which are not immediately hazardous, but may become so.

- (d) ~~Secondary alarms~~ – all other alarms.

Cautions – awareness of a condition which still requires attention out of the ordinary consideration of the situation or of given information.

5.5.4 Appropriate alarm management ~~on general and functional levels~~ is to be provided. This includes prioritisation, distribution and recording of alarms ~~and other alerts~~ as required.

5.5.5 Within each priority, ~~alarms alerts~~ are to be arranged in groups, in order to reduce the quantity of information presented to the operator. More detailed information on the group alarm is to be readily available from the integrated bridge system on request.

5.5.8 ~~Alarms Alerts~~ are to be displayed in order of priority. Within the priorities, ~~alarms alerts~~ are to be displayed in the order in which they occur. The visual display units are to provide immediate display of new ~~alarm~~ information, regardless of the information display page currently selected. This may be achieved by provision of a dedicated ~~alarm alert~~ monitor, a dedicated area of screen for ~~alarms alerts~~ or other suitable means.

5.5.10 The centralised alarm system is to be capable of displaying at least 20 items simultaneously. There is to be a clear and unambiguous indication that there are additional items requiring attention when the display does not show all active alerts simultaneously, and it is to be possible to display the additional messages and to return to the display containing the highest priority items by single operator actions.

5.5.11 Alerts are to be acknowledged individually. It is to be possible temporarily to silence all audible signals with a single operator action.

5.5.12 The characteristics of audible warning and, where provided, caution signals are to be such that it is possible to differentiate these from audible alarm signals.

Part 7, Chapters 13 and 16

Part 7, Chapter 13 Passenger and Crew Accommodation Comfort

Effective date 1 July, 2012

■ *Section 1* **General requirements**

1.1 Scope

1.1.7 The sound pressure levels for audible alarms and public address systems fitted in accordance with other sections of the Rules are to satisfy IMO Resolution ~~A.930(19)~~ ~~Code on Alarms and Indicators~~ A.1021(26) *Code on Alerts and Indicators*, 2009.

Part 7, Chapter 16 Passenger and Crew Accommodation Comfort

Effective date 1 July, 2012

■ *Section 2* **Construction and installation**

2.2 Equipment – Selection and installation

2.2.1 Pressure vessels in provision store and air conditioning refrigeration systems are to be in accordance with Pt 5, Ch 11 ~~or an alternative recognised code acceptable to LR.~~

Section numbering in brackets reflects any Section renumbering necessitated by any of the Notices that update the current version of the Rules for Ships.

Part 1, Chapter 3

21.1.1 *Reference Ch 2,2.5.1 now reads Ch 2,2.6.1*

Part 3, Chapter 2

3.5.3 *Reference Pt 6, Ch 2,13.10 now reads Pt 6, Ch 2,14.10*

Part 3, Chapter 11

8.5.7 *Reference Pt 6, Ch 2,18 now reads Pt 6, Ch 2,19*

Part 4, Chapter 2

8.5.7 *Reference Pt 6, Ch 2,18 now reads Pt 6, Ch 2,19*
 9.7.1(h) *Reference Pt 6, Ch 2,18 now reads Pt 6, Ch 2,19*
 9.10.1 *Reference Pt 6, Ch 2,13.13.4 now reads Pt 6, Ch 2,14.13.4*

Part 4, Chapter 9

1.2.8 *Reference Pt 6, Ch 2,13 now reads Pt 6, Ch 2,14*
 1.2.9 *Reference Pt 6, Ch 2,13 now reads Pt 6, Ch 2,14*
 7.1.5 *Reference Pt 6, Ch 2,13 now reads Pt 6, Ch 2,14*

Part 5, Chapter 1

3.8.1 *Table 2.18.1 now reads Table 2.11.1*

Part 5, Chapter 2

1.1.1 *Reference 11.1.4 now reads 13.1.4*
Reference 11.2.3 now reads 13.2.3
Reference 11.4 now reads 13.4
Reference 11.5 now reads 13.5
Reference 15.2 now reads 1.1.7 and 1.1.8
 1.1.2 *Section 10 now reads Section 14*
 1.1.4 *Reference 8.11 now reads 9.1*
 Table 2.2.1 *Section 11 now reads Section 13*
 6.1.3 (10.1.4) *Section 13 now reads Section 18*
 6.8.1 (10.8.1) *Section 14 now reads Section 19*
 8.1.2 (16.1.2) *Reference 8.12 now reads 9.2*
Reference 8.11 now reads 9.1
 8.3.2 (16.3.2) *Reference 8.3.1 now reads 16.3.1*
 8.4.1 (16.4.1) *Reference 8.4.2 to 8.4.6 now reads 16.4.2 to 16.4.6*
 8.4.2 (16.4.2) *Table 2.8.1 now reads Table 2.9.1*

8.4.4 (16.4.4) *Reference 8.4.2 now reads 16.4.2*
 8.4.5 (16.4.5) *Reference 8.4.2 now reads 16.4.2*
 8.7.6 (16.7.6) *Reference 8.7.3 now reads 16.7.3*
 8.11.2 (9.1.2) *Reference 8.11.1 now reads 9.1.1*
 8.11.5 (9.1.5) *Reference 8.11.3 now reads 9.1.3*
Reference 8.11.4 now reads 9.1.4
 8.13.1 (9.3.1) *Reference 8.12 now reads 9.2*
 8.13.4 (9.3.4) *Reference 8.13.1 now reads 9.3.1*
Reference 8.13.3 now reads 9.3.3
 8.13.6 (9.3.6) *Reference 8.13.1 now reads 9.3.1*
Reference 8.13.2 now reads 9.3.2
 8.14.5 (9.4.5) *Reference 8.14.2 now reads 9.4.2*
Reference 8.14.3 now reads 9.4.3
 8.14.6 (9.4.6) *Reference 8.13.2 to 8.13.5 now reads 9.3.2 to 9.3.5*
Reference 8.15.1 now reads 9.5.1
 9.1.1 (12.1.1) *Table 2.9.1 now reads Table 2.12.1 (twice)*
 9.1.2 (12.1.2) *Table 2.9.1 now reads Table 2.12.1*
 10.5.2 (14.3.2) *Reference 10.5.1 now reads 14.3.1*
 11.1.2 (13.1.2) *Reference 11.1.1(a) now reads 13.1.1(a)*
 11.1.3 (13.1.3) *Reference 9.1.1 now reads 12.1.1*
 11.1.4 (13.1.4) *Reference 11.1.1(a) now reads 13.1.1(a)*
 11.2.1 (13.2.1) *Reference 11.2.2 to 11.2.5 now reads 13.2.2 to 13.2.5*
 11.2.4 (13.2.4) *Reference 11.5 now reads 13.5*
 11.4.1 (13.4.1) *Reference 11.2.4 now reads 13.2.4*
 11.5.5 (13.5.5) *Reference 11.5.11 now reads 13.5.1*
Reference 11.5.12 now reads 13.5.2
Reference 11.5.4 now reads 13.5.4
 11.5.6 (13.5.6) *Reference 11.5.4 now reads 13.5.4*
 11.5.9 (13.5.9) *Reference 11.5.8 now reads 13.5.8*
 Table 2.12.2 *Reference 18.1.7 now reads 11.1.7*
 (Table 2.15.2) *Section 8 now reads Section 9*
Reference 18.2.3 now reads 11.2.3
 12.1.1 (15.1.1) *Reference 11.1 now reads 13.1*
 12.2.1 (15.2.1) *Reference 12.2.2 to 12.2.5 now reads 15.2.2 to 15.2.5*
 12.2.2 (15.2.2) *Reference 10.1.1 now reads 1.1.10*
 12.2.4 (15.2.4) *Reference 10.2 now reads 17.3*
 12.3.1 (15.3.1) *Reference 12.3.3 to 12.3.7 now reads 15.3.3 to 15.3.7*
 12.3.2 (15.3.2) *Reference 12.3.4 to 12.3.7 now reads 15.3.4 to 15.3.7*
 12.3.5 (15.3.5) *Table 2.9.1 now reads Table 2.12.1*
 12.3.6 (15.3.6) *Reference 14.3 now reads 19.3*
Reference 14.4 now reads 19.4
 12.3.7 (15.3.7) *Reference 10.5 now reads 14.3*
 12.4.1 (15.4.1) *Reference 12.2.4 now reads 15.2.4*
 13.3.1(l) *Reference 13.4.3 now reads 18.4.3*
 (18.3.1(l))
 13.5.1 (18.5.1) *Reference 13.5.3 now reads 18.5.3*
 13.5.2 (18.5.2) *Reference 13.5.3 now reads 18.5.3*
Reference 13.6 now reads 18.6
Reference 13.8 now reads 18.8
 13.6.3 (18.6.3) *Reference 13.7.1(f) now reads 18.7.1(f)*
 13.7.1(a) *Reference 13.5.1 now reads 18.5.1*
 (18.7.1(a))
 13.8.3 (18.8.3) *Reference 13.6 now reads 18.6*
Reference 13.7 now reads 18.7
 13.8.3(b) *Reference 13.3.1(m) now reads 18.3.1(m)*
 (18.8.3(b)) *Reference 13.5.3 now reads 18.5.3*
Reference 13.6.4 now reads 18.6.4
Reference 13.6.4(a) now reads 18.6.4(a)
 13.8.3(c) *Reference 13.7 now reads 18.7*
 (18.8.3(c)) *Reference 13.7.1(f) now reads 18.7.1(f)*

Cross-references

13.8.4 (18.8.4)	Reference 13.6 now reads 18.6 Reference 13.7 now reads 18.7
13.8.4(b)	Reference 13.3.1(m) now reads 18.3.1(m)
(18.8.4(b))	Reference 13.5.3 now reads 18.5.3 Reference 13.6.4 now reads 18.6.4 Reference 13.6.4(a) now reads 18.6.4(a)
13.8.4(c)	Reference 13.7 now reads 18.7
(18.8.4(c))	Reference 13.7.1(f) now reads 18.7.1(f)
13.9.1(h)	Reference 13.7 now reads 18.7
(19.1.2(b))	
14.1.2(b)	Reference 14.10 now reads 19.10
(19.1.2(b))	
14.4.1(a)	Reference 14.5 now reads 19.5
(19.4.1(a))	
14.4.2(a)	Reference 14.5 now reads 19.5
(19.4.2(a))	
14.5.1 (19.5.1)	Reference 14.5.2 to 14.5.6 now reads 19.5.2 to 19.5.6
14.5.2 (19.5.2)	Reference 14.5.2(a) now reads 19.7.2(a)
14.5.8 (19.5.8)	Reference 14.4.2(e) now reads 19.4.2(e)
14.7.1 (19.7.1)	Reference 14.7 now reads 19.7
14.8.1 (19.8.1)	Reference 14.6.1 now reads 19.6.1
15.2.1(c)	Reference 15.3 now reads 4.2
(1.1.7(c))	
15.2.2(a)	Reference 15.5.2 now reads 4.3.2
(1.1.8(a))	
15.3.2(c)	Reference Pt 6, Ch 1,2,3.12 now reads Pt 6, Ch 1,2,3.14
(4.2.2(c))	Reference 15.3.2(a) now reads 4.2.2(a)
15.3.3 (4.2.3)	Reference Pt 6, Ch 1,2,10.21 to be deleted.
15.6.1 (4.4.1)	Reference 15.6.1 now reads 4.4.1
15.6.3 (4.4.3)	Reference 15.6.2 now reads 4.4.2
15.6.3(a)	Reference 15.2.2(b) now reads 1.1.8(b)
(4.4.3(a))	
17.1.3 (6.1.3)	Reference 17.1.2 now reads 6.1.2
Table 2.18.1	Reference 5.2 now reads 7.2
(Table 2.11.1)	Reference 5.4 now reads 7.4 (twice) Reference 5.3 now reads 7.3
18.1.1 (11.1.1)	Reference 18.1.2 to 18.1.10 now reads 11.1.2 to 11.1.10
18.1.2(a)	Reference 15.2.1(h) now reads 1.1.7(h)
(11.1.2(a))	
18.1.2(b)	Reference 15.5.2 now reads 4.3.2
(11.1.2(b))	
18.1.10 (11.1.10)	Table 2.18.1 now reads Table 2.11.1
18.2.1 (11.2.1)	Table 2.12.2 now reads Table 2.11.2 Reference 18.1.7 now reads 11.1.7 Reference 18.2.3 now reads 11.2.3
Table 2.18.2	Reference 18.1.7 now reads 11.1.7
(Table 2.11.2)	Reference 18.2.3 now reads 11.2.3 Section 8 now reads Section 16
18.2.3 (11.2.3)	Reference 18.2.2 now reads 11.2.2
18.2.5(a)	Reference 15.2.1(h) now reads 1.1.7(h)
(11.2.5(a))	
18.2.5(b)	Reference 15.5.2 now reads 4.3.2
(11.2.5(b))	

Part 5, Chapter 9

1.1.3	Reference Pt 6, Ch 2,15 now reads Pt 6, Ch 2,16
2.5.1	Reference Pt 6, Ch 2,15.2.2 now reads Pt 6, Ch 2,16.2.2
6.5.3	Reference Ch 14,8.9.6 now reads Ch 14,8.13.6

6.7.2	Reference Pt 6, Ch 2,8.6 now reads Pt 6, Ch 2,9.6
7.1.4	Reference 10.4.3 now reads 11.4.3
7.2.1(f)	Reference Pt 6, Ch 2,1.9 now reads Pt 6, Ch 2,1.10
8.1.5	Reference 15.4.7 now reads 16.4.7
8.1.6	Reference 1.9 now reads 1.10
8.2.1	Reference Pt 6, Ch 2,15 now reads Pt 6, Ch 2,16
8.5.2	Reference Pt 6, Ch 2,1.9 now reads Pt 6, Ch 2,1.10
1.10.4 (1.11.4)	Reference 1.9 now reads 1.10
10.17.4	Reference 1.9 now reads 1.10
Table 9.8.1	Reference Pt 6, Ch 2,15.1.3 now reads Pt 6, Ch 2,16.1.3 Reference Pt 6, Ch 2,15.4.9 now reads Pt 6, Ch 2,16.4.9

Part 5, Chapter 10

1.6.3	Reference 3.5 now reads Pt 5, Ch 10,18.3 Reference 3.6 now reads Pt 5, Ch 14,12.2
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Part 5, Chapter 11

9 (x-ref)	Reference Ch 2,7 now reads Ch 2,8
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Part 5, Chapter 12

4.2.3	Reference Ch 2,7.4.3 now reads Ch 2,8.3.4
5.5.2	Reference Pt 6, Ch 2,1.12 now reads Pt 6, Ch 2,1.13
5.7.9	Reference Pt 6, Ch 2,1.12 now reads Pt 6, Ch 2,1.13
5.8.2	Reference 20.2.3 now reads 21.2.3

Part 5, Chapter 13

8.1.1	Reference 6.1.7 has been deleted
8.1.2	Reference 6.1.7 has been deleted

Part 5, Chapter 14

2.9.2	Reference Ch 2,7 now reads Ch 2,8
3.1.11	Reference 3.5 to 3.8 now reads Pt 5, Ch 10,18.3, Pt 5, Ch 14,12.2 and Pt 5, Ch 14,12.3
3.3.2	Reference Ch 2,8.11 now reads Ch 2,9.1
6.2.7	Reference Pt 6, Ch 1,3.1.3 now reads Pt 5, Ch 4,8.8.3
7.3.1	Reference Ch 3,6.3 now reads Ch 3,7.3
10.1.3	Reference Ch 2,8 now reads Ch 2,9
10.2.4	Reference Ch 2,8 now reads Ch 2,9

Part 5, Chapter 15

1.5.2	Reference Pt 6, Ch 2,13.5 now reads Pt 6, Ch 2,14.5
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1.5.3	<i>Reference Pt 6, Ch 2,1.12 now reads Pt 6, Ch 2,1.13</i>
1.6.4 (1.6.5)	<i>Reference 1.6.5 now reads 1.6.6 Reference 1.6.6 now reads 1.6.7</i>
2.7.1(b)	<i>Reference Pt 6, Ch 2,13.5 now reads Pt 6, Ch 2,14.5</i>
3.5.2	<i>Reference Pt 6, Ch 2,13.10 now reads Pt 6, Ch 2,14.10</i>
3.8.1	<i>Reference Pt 6, Ch 2,13.2 now reads Pt 6, Ch 2,14.2</i>

Part 5, Chapter 20

5.2.1	<i>Reference Pt 6, Ch 2,15.3.5 now reads Pt 6, Ch 2,16.3.5</i>
5.4.1	<i>Reference Pt 6, Ch 2,8.4.2 now reads Pt 6, Ch 2,9.4.2 Reference Pt 6, Ch 2,8.4.7 now reads Pt 6, Ch 2,9.4.7</i>

Part 5, Chapter 21

1.3.3	<i>Reference Pt 6, Ch 2,13 now reads Pt 6, Ch 2,14</i>
1.3.4	<i>Reference Pt 6, Ch 2,10 now reads Pt 6, Ch 2,11</i>

Part 5, Chapter 23

2.1.2(g)	<i>Reference Pt 6, Ch 2,14.5 now reads Pt 6, Ch 2,15.6</i>
2.1.3	<i>Reference Pt 6, Ch 2,1.15 now reads Pt 6, Ch 2,1.16 Reference Pt 6, Ch 2,1.16 now reads Pt 6, Ch 2,1.17</i>
2.1.3(a)(i)	<i>Reference 17.2 now reads 18.2</i>
2.1.3(a)(ii)	<i>Reference 17.3 now reads 18.3</i>
2.1.3(a)(iii)	<i>Reference 16.10.3 now reads 17.10.3</i>
2.1.3(b)	<i>Reference Pt 6, Ch 2,16.4 now reads Pt 6, Ch 2,17.4</i>
2.1.3(c)(i)	<i>Reference 16.2 now reads 17.2</i>
2.1.3(c)(ii)	<i>Reference 16.5 now reads 17.5</i>
2.1.3(c)(iii)	<i>Reference 16.9 now reads 17.9</i>
2.1.3(d)	<i>Reference 16.1 now reads 17.1</i>
2.1.3(e)	<i>Reference Pt 6, Ch 2,18.1 now reads Pt 6, Ch 2,19.1</i>
2.1.3(f)	<i>Reference 17.1 now reads 18.1 Reference 17.4 now reads 18.4</i>
4.1.2	<i>Reference Pt 6, Ch 2,1.15 now reads Pt 6, Ch 2,1.16</i>
2.1.2(b)(i)	<i>Reference 17.2 now reads 18.2</i>
2.1.2(b)(ii)	<i>Reference 17.3 now reads 18.3</i>
2.1.2(b)(iii)	<i>Reference 16.10.3 now reads 17.10.3</i>
4.1.2(d)	<i>Reference 17.1 now reads 18.1 Reference 17.4 now reads 18.4</i>
4.1.2(a)	<i>Reference 16.4 now reads 17.4</i>

Part 6, Chapter 1

Table 1.3.9	<i>Reference Ch 2,15 now reads Ch 2,16</i>
1.2.5(f))	<i>Reference 2.10.25 now reads 2.10.20</i>
1.2.10	<i>Reference Ch 2,10 now reads Ch 2,11</i>

2.3.1	<i>Reference 2.3.18 now reads 2.3.20</i>
2.6.3(b)	<i>Reference 3.10 now reads Pt 5, Ch 7,5.3</i>
2.6.5	<i>Reference 2.2.5 now reads 2.2.6</i>
2.8.7	<i>Reference 16.1 now reads 17.1</i>
2.9.2	<i>Reference 16.3.4 now reads 17.3.4</i>
2.9.3	<i>Reference 16.3.12 now reads 17.3.12</i>
2.10.12	<i>Reference Ch 2,1.2.12 now reads Ch 2,1.2.15 Reference 11.7 now reads 12.7</i>
2.10.21	<i>Reference Pt 6, Ch 2,1.5.1 now reads Pt 6, Ch 2,1.6.1</i>
2.11.9	<i>Reference Ch 2,10 now reads Ch 2,11</i>
2.13.1	<i>Reference Ch 2,1.5 now reads Ch 2,1.6</i>
2.14.1	<i>Reference 16 to 18 now reads 17 to 19</i>
2.14.7	<i>Reference 2.10.23 now reads 2.10.18 Reference 2.10.24 now reads 2.10.19</i>
3.2.7	<i>Reference 16.3.13 now reads Pt 5, Ch 2,9.3</i>
4.2.3	<i>Reference 2.2.3 now reads 2.2.4</i>
6.3.1	<i>Reference 2.10.20 now reads 2.10.16</i>

Part 6, Chapter 2

1.2.5 (1.2.8)	<i>Reference Section 13 now reads Section 14</i>
1.2.6 (1.2.9)	<i>Reference 13.2 now reads 14.2 Reference 13.3 now reads 14.3 Reference 15.4 now reads 16.4</i>
1.2.7(g) (1.2.10(g))	
1.2.9 (1.2.12)	<i>Reference 16.3.10 now reads 17.3.10 Reference 16.3.9 now reads 17.3.9</i>
1.2.11 (1.2.14)	<i>Reference 11.5 now reads 12.5</i>
1.2.12 (1.2.15)	<i>Reference 11.7 now reads 12.7</i>
1.2.13 (1.2.16)	<i>Reference 10.8 now reads 11.8</i>
1.2.14 (1.2.17)	<i>Reference 8.1.10 now reads 9.1.10</i>
1.2.15 (1.3.2)	<i>Reference 10.8.10 now reads 11.8.10</i>
1.2.16 (1.3.16)	<i>Reference 1.10.2 now reads 1.11.2</i>
1.2.20	<i>Reference 10.13 now reads 11.13 Reference 1.6.3 now reads 1.7.3</i>
1.3.2 (1.4.2)	<i>Reference 1.3.2 now reads 1.4.2 Reference 15.5.8 now reads 16.5.8</i>
1.3.3 (1.4.3)	<i>Reference 1.3.2 now reads 1.4.2</i>
1.3.5 (1.4.5)	<i>Reference 1.3.2 to 1.3.4 now reads 1.4.2 to 1.4.4</i>
1.4.3 (1.5.3)	<i>Reference 11.3 now reads 12.3 Reference 11.4 now reads 12.4 Reference 11.5.9 now reads 12.5.9</i>
1.4.4 (1.5.4)	<i>Reference 1.2.3 now reads 1.2.5 Reference 1.2.4 now reads 1.2.6</i>
1.4.5 (1.5.5)	<i>Reference 14.5 now reads 19.5 Reference 14.5.5 now reads 15.6.5 Reference 14.5.6 now reads 15.6.6</i>
1.5.3 (1.6.3)	<i>Reference 1.5.1 now reads 1.6.1 Reference 1.5.2 now reads 1.6.2</i>
1.5.11 (1.6.11)	<i>Reference Pt 5, Ch 2,8.14 now reads Pt 5, Ch 2,9.4</i>
1.8.5 (1.9.6)	<i>Reference 1.8.4 now reads 1.9.4</i>
1.8.6 (1.9.7)	<i>Reference 1.8.4 now reads 1.9.4</i>
1.10.1(a) (1.11.1(a))	<i>Reference 1.11.2(h) now reads 1.12.2(h)</i>
1.10.3(c) (1.11.3(c))	<i>Reference 1.8 now reads 1.9</i>
1.10.3(d) (1.11.3(d))	<i>Reference Section 13 now reads Section 14</i>
1.10.7 (1.11.7)	<i>Reference 10.15 now reads 11.15</i>

Cross-references

1.11.1 (1.12.1)	Reference 1.11.2 now reads 1.12.2	9.1.13 (10.1.13)	Reference 1.3.2 now reads 1.4.2
1.11.2 (1.12.2)	Reference 1.11.1 now reads 1.12.1		Reference 1.3.3 now reads 1.4.3
1.11.4 (1.12.4)	Reference 13.9.4 now reads 14.9.3	9.1.13(d)	Reference 9.1.9 now reads 10.1.9
1.11.6 (1.12.6)	Reference 1.11.2 now reads 1.12.2	(10.1.13 (d))	
1.13.3 (1.14.3)	Reference 1.15 now reads 1.16	9.2.1 (10.2.1)	Reference 9.2.2 to 9.2.18 now reads 10.2.2 to 10.2.18
1.13.4 (1.14.4)	Reference 1.15 now reads 1.16		
1.15.1 (1.16.1)	Reference 16.6 now reads 17.6	9.2.2 (10.2.2)	Reference 1.8 now reads 1.9
	Reference 17.4.3 now reads 18.4.3	9.2.11 (10.2.11)	Reference 1.7.3 now reads 1.8.3
1.15.2 (1.16.2)	Reference 10.5.3 now reads 11.5.3	9.2.16 (10.2.16)	Reference 1.7 now reads 1.8
	Reference 1.15.1 now reads 1.16.1	9.2.18 (10.2.18)	Reference 1.3.2 now reads 1.4.2
1.15.3 (1.16.3)	Reference 10.5.3 now reads 11.5.3	9.3.1 (10.3.1)	Reference 9.1 to 9.2 now reads 10.1 to 10.2
1.15.3 (1.16.3)	Reference 1.15.1 now reads 1.16.1		
1.15.4 (1.16.4)	Reference 1.15.1 now reads 1.16.1	9.3.1 (10.3.1)	Section 11 now reads Section 12
1.15.5 (1.16.5)	Reference 1.10.4 now reads 1.11.4	9.3.8 (10.3.8)	Reference 11.3.5 now reads 12.3.5
1.18.2 (1.19.2)	Reference 1.17.1 now reads 1.18.1	9.3.10 (10.3.10)	Reference 1.4 now reads 1.5
2.2.1(a)	Reference 15.3.5 now reads 16.3.5	9.3.12 (10.3.12)	Reference 1.3.2 now reads 1.4.2
2.3.1	Reference Pt 5, Ch 2,8 now reads Pt 5, Ch 2,9	10.1.1 (11.1.1)	Reference 10.1 to 10.16 now reads 11.1 to 11.16
			Reference 10.17 now reads 11.17
2.3.2	Reference Pt 5, Ch 2,8.11.1 now reads Pt 5, Ch 2,9.1.1	10.1.2 (11.1.2)	Table 2.10.1 now reads Table 2.11.1
2.2.3	Reference 1.5.1 now reads 1.6.1	10.2.1 (11.2.1)	Reference 10.1.3 now reads 11.1.3
2.4.1	Reference Pt 5, Ch 2,5.3 now reads Pt 5, Ch 2,7.3	10.2.1(b)	Section 20 now reads Section 21
		(11.2.1(b))	
2.4.2	Reference 1.7.2 now reads 1.8.2	10.2.2 (11.2.2)	Reference 10.1.2 now reads 11.1.2
3.2.7(h)	Reference 16.11.1 now reads 17.11.1	10.4.2 (11.4.2)	Reference 10.1.2 now reads 11.1.2
3.4.1	Reference 8.14 now reads 9.4		Table 2.10.2 now reads Table 2.11.2
5.1.2(e)	Reference 13.1.2 now reads 14.1.2	10.4.3 (11.4.3)	Table 2.10.2 now reads Table 2.11.2
5.2.4	Reference Pt 6, Ch 2,1.12 now reads Pt 6, Ch 2,1.13		Reference 10.1.2 now reads 11.1.2
		10.5.2 (11.5.2)	Reference 10.5.1 now reads 11.5.1
5.3.8	Reference 13.1.2 now reads 14.1.2	10.5.5 (11.5.5)	Reference 10.8.7 now reads 11.8.7
5.4.3	Reference 13.1.2 now reads 14.1.2		Reference 10.8.8 now reads 11.8.8
5.5.7	Reference 13.1.2 now reads 14.1.2	10.6.1 (11.6.1)	Reference 10.7 now reads 11.7
5.7.4	Section 17 now reads Section 18	10.6.3 (11.6.3)	Table 2.10.2 now reads Table 2.11.2
5.8.1	Reference 1.5.1 now reads 1.6.1		Table 2.10.3 now reads Table 2.11.3
6.1.4	Reference 1.2.3 now reads 1.2.5		Table 2.10.4 now reads Table 2.11.4
	Reference 1.2.4 now reads 1.2.6		(twice)
6.1.7	Reference 11.3.5 now reads 12.3.5	10.6.4 (11.6.4)	Reference 1.7 now reads 1.8
6.9.1(b)	Reference 1.5.2 now reads 1.6.2	10.6.5 (11.6.5)	Reference 1.11.8 now reads 1.12.8
6.9.3	Reference 15.3 now reads 16.3	10.6.6 (11.6.6)	Reference 10.7.4 now reads 11.7.4
7.18.1	Reference 1.3.2 now reads 1.4.2	10.7.1 (11.7.1)	Reference 10.7.2 to 10.7.5 now reads 11.7.2 to 11.7.5
7.18.2	Section 20 now reads Section 21		
8.1.2 (9.1.2)	Reference 1.3.2 to 1.3.4 now reads 1.4.2 to 1.4.4	10.7.3 (11.7.3)	Table 2.10.3 now reads Table 2.11.3
			Table 2.10.5 now reads Table 2.11.5
8.1.9 (9.1.9)	Reference 15.1.3 to now reads 16.1.3	10.8.2 (11.8.2)	Table 2.10.6 now reads Table 2.11.6
8.1.14 (9.1.14)	Reference 8.1.10 now reads 9.1.10	10.8.13 (11.8.13)	Reference 1.11 now reads 1.12
8.2.1 (9.2.1)	Reference 8.3 now reads 9.3 (twice)	10.8.17 (11.8.17)	Reference 10.9 now reads 11.9
8.3.1 (9.3.1)	Reference 1.8 now reads 1.9	10.8.18 (11.8.18)	Reference 10.10 now reads 11.10
	Table 2.8.1 now reads Table 2.9.1	10.8.19 (11.8.19)	Reference 10.11 now reads 11.11
8.3.2 (9.3.2)	Reference 1.8 now reads 1.9	10.8.20 (11.8.20)	Reference 10.12 now reads 11.12
8.3.3 (9.3.3)	Reference 1.8 now reads 1.9 (twice)	10.8.21 (11.8.21)	Reference 10.14 now reads 11.14
8.8.1 (9.8.1)	Reference 1.3.2 to 1.3.4 now reads 1.4.2 to 1.4.4		Reference 10.5.7 now reads 11.5.7
		10.9.3 (11.9.3)	Reference 1.11 now reads 1.12
8.8.2 (9.8.2)	Section 15 now reads Section 16	10.10.1 (11.10.1)	Reference 10.8.4 now reads 11.8.4
8.8.3 (9.9.3)	Section 20 now reads Section 21	10.10.3 (11.10.3)	Table 2.10.7 now reads Table 2.11.7
8.8.4 (9.8.4)	Reference Pt 6, Ch 2,1.3 now reads Pt 6, Ch 2,1.4	10.10.4 (11.10.4)	Table 2.10.7 now reads Table 2.11.7
		10.12.3 (11.12.3)	Reference 10.8.2 now reads 11.8.2
8.8.5 (9.8.5)	Reference 8.1.10 now reads 9.1.10	10.13.1 (11.13.1)	Reference 10.8.14(b) now reads 11.8.14(b)
Table 2.8.1	Reference 1.8 now reads 1.9		
(Table 2.9.1)		10.15.1 (11.15.1)	Reference 1.10.7 now reads 1.11.7
8.13.1 (9.13.1)	Reference Pt 6, Ch 2,11 now reads Pt 6, Ch 2,12	10.16.3 (11.16.3)	Reference 10.5.3 now reads 11.5.3
		10.17.1 (11.17.1)	Reference 10.17.2 to 10.17.6 now reads 11.17.2 to 11.17.6
9.1.1 (10.1.1)	Reference 9.1.2 to 9.1.13 now reads 10.1.2 to 10.1.13		
		11.3.2 (12.3.2)	Reference 11.3.1 now reads 12.3.1
9.1.2 (10.1.2)	Reference 1.8 now reads 1.9	11.3.4 (12.3.4)	Reference 11.3.1 now reads 12.3.1
9.1.4 (10.1.4)	Reference 1.8 now reads 1.9		Reference 11.3.2 now reads 12.3.2
9.1.6 (10.1.6)	Reference 1.7 now reads 1.8		Reference 11.3.3 now reads 12.3.3

11.3.5 (12.3.5)	Reference 11.6.4 now reads 12.6.4 Reference 11.6.5 now reads 12.6.5 Reference 11.5.10 now reads 12.5.10	Reference 13.4 now reads 14.4 Reference 13.14.4 to 13.14.7 now reads 14.14.4 to 14.14.7
11.3.10 (12.3.10)	Reference 11.3.1 now reads 12.3.1	13.14.6 (14.14.6) Reference 13.5.3 now reads 14.5.3
11.3.11 (12.3.11)	Reference 1.4.3 now reads 1.5.3	13.15.6(a) Reference 13.5.5(a) now reads 14.5.5(a)
11.5.1 (12.5.1)	Reference 11.5.2 now reads 12.5.2	(14.15.6(a))
11.5.5 (12.5.5)	Reference 11.5.9 now reads 12.5.9	14.1.1 (15.1.1) Reference 14.1.2 to 14.1.7 now reads 15.1.2 to 15.1.7
11.5.6 (12.5.6)	Reference 11.3.2 now reads 12.3.2 Reference 11.3.3 now reads 12.3.3 Reference 11.3.5 now reads 12.3.5	14.1.6 (15.1.6) Reference 14.1.5 now reads 15.1.5
11.5.11 (12.5.11)	Reference 11.5.8 now reads 12.5.8	14.5.5 (15.5.5) Reference 1.4.5 now reads 1.5.5
11.7.2 (12.7.2)	Reference 1.4.3 now reads 1.5.3	14.5.5 (15.6.5) Reference 14.5.4 now reads 15.6.4
11.7.3 (12.7.3)	Reference 1.4.2 now reads 1.5.2	14.5.6 (15.6.6) Reference 14.5.5 now reads 15.6.5
12.3.1 (13.3.1)	Table 2.12.1 now reads Table 2.13.1	14.5.7 (15.6.7) Reference 14.5.1 now reads 15.6.1
12.4.1 (13.4.1)	Table 2.12.1 now reads Table 2.13.1	14.5.8 (15.6.8) Reference 14.5.4 now reads 15.6.4 Reference 14.5.5 now reads 15.6.5
13.1.4 (14.1.4)	Section 11 now reads Section 12	14.5.9 (15.6.9) Reference 14.5.1 now reads 15.6.1
13.1.13 (14.1.13)	Reference 13.2 now reads 14.2 Reference 13.3 now reads 14.3	Table 2.15.1 Reference 15.1.2 now reads 16.1.2
13.2.1 (14.2.1)	Reference 13.2.4 now reads 14.2.4 Reference 13.2.5 now reads 14.2.5 Reference 13.2.6 now reads 14.2.6	(Table 2.16.1) Reference 15.3.9 now reads 16.3.9 Reference 9.1.11 now reads 10.1.11 Reference 15.5.6 now reads 16.5.6 Reference 15.1.3 now reads 16.1.3 Reference 8.1.10 now reads 9.1.10 Reference 8.1.11 now reads 9.1.11 Reference 15.4.8 now reads 16.4.8 Reference 15.4.9 now reads 16.4.9
13.2.2 (14.2.2)	Reference 13.5 now reads 14.5	15.1.3 (16.1.3) Reference 8.1.9 now reads 9.1.9
13.2.3 (14.2.3)	Reference 13.2.4 now reads 14.2.4	15.5.7 (16.5.7) Reference 1.7 now reads 1.8
13.2.3 (14.2.3)	Reference 13.2.5 now reads 14.2.5	15.5.10 (16.5.10) Reference 9.2.4 now reads 10.2.4
13.2.9 (14.2.9)	Reference 13.10 to 13.12 now reads 14.10 to 14.12	15.5.11 (16.5.11) Table 2.15.1 now reads Table 2.16.1
13.3.1 (14.3.1)	Reference 13.5.3 now reads 14.5.3	16.1.2 (17.1.2) Reference 1.13 now reads 1.14 Reference 1.15 now reads 1.16
13.3.3 (14.3.3)	Reference 13.5.3 now reads 14.5.3	16.1.6 (17.1.6) Reference 16.1.7 to 16.1.19 now reads 17.1.8 to 17.1.18
13.3.3(e)	Reference 13.2.5 now reads 14.2.5	16.3.3 (17.3.3) Reference 1.13 now reads 1.14 Reference 1.14 now reads 1.15
(14.3.3(e))	Reference 13.2.6 now reads 14.2.6	16.3.5 (17.3.5) Reference 16.3.6 to 16.3.10 now reads 17.3.6 to 17.3.10
13.5.1 (14.5.1)	Reference 13.10 to 13.14 now reads 14.10 to 14.14	16.3.8 (17.3.8) Reference 1.10.1 now reads 1.11.1
13.5.4 (15.5.4)	Reference 13.10 to 13.14 now reads 14.10 to 14.14	16.3.9 (17.3.9) Reference 1.2.9 now reads 1.2.12 Reference 16.3.8 now reads 17.3.8
13.5.3 (14.5.3)	Reference 13.14 now reads 14.14	16.3.9(a) Reference 16.3.6 and 16.3.7 now reads 17.3.6 and 17.3.7
13.5.6(b)	Reference 13.5.5(b) now reads 14.5.5(b)	(17.3.9(a))
(14.5.6(b))		16.3.10 (17.3.10) Reference 16.3.9 now reads 17.3.9
13.5.7(a)	Reference 13.5.5(d) now reads 14.5.5(d)	16.3.11 (17.3.11) Reference 16.3.12 to 16.3.14 now reads 17.3.12 to 17.3.14
(14.5.7(a))		16.6.3 (17.6.3) Reference 16.6.2 now reads 17.6.2
13.5.7(b)	Reference 13.5.5(a) now reads 14.5.5(a)	16.6.4 (17.6.4) Reference 16.6.2 now reads 17.6.2
(14.5.7(b))		16.6.5 (17.6.5) Reference 16.6.2 now reads 17.6.2
13.5.7(c)	Reference 13.5.5(b) now reads 14.5.5(b)	16.6.10 (17.6.10) Reference 10.5.3 now reads 11.5.3
(14.5.7(c))		16.7.1 (17.7.1) Reference 1.13 now reads 1.14 Reference 1.15 now reads 1.16
13.5.7(d)	Reference 13.5.5(b) now reads 14.5.5(b)	16.9.1 (17.9.1) Reference 1.13 now reads 1.14 (twice) Reference 1.15 now reads 1.16
(14.5.7(d))	Reference 13.7 now reads 14.7	16.9.2 (17.9.2) Reference 1.5.1 now reads 1.6.1
13.5.7(e)	Reference 13.5.5(a) now reads 14.5.5(a)	16.10.5 (17.10.5) Reference 16.10.4 now reads 17.10.4
(14.5.7(f))		17.1.3 (18.1.3) Reference 17.4 now reads 18.4
13.5.7(f)	Reference 13.5.5(b) now reads 14.5.5(b)	17.2.1 (18.2.1) Reference 1.13 now reads 1.14 Reference 1.15 now reads 1.16
(14.5.7(g))		17.2.2 (18.2.2) Reference 1.13 now reads 1.14
13.5.7(g)	Reference 13.5.5(e) now reads 14.5.5(e)	17.2.6 (18.2.6) Reference 20.2 now reads 21.2
(14.5.7(h))		17.3.2 (18.3.2) Reference 1.13 now reads 1.14 Reference 1.15 now reads 1.16
13.5.7(h)	Reference 13.5.5(a) now reads 14.5.5(a)	17.3.9 (18.3.9) Reference 17.2 now reads 18.2
(14.5.7(i))		17.3.11 (18.3.11) Reference 20.2 now reads 21.2
13.5.8(b)	Reference 13.5.7(d) now reads 14.5.7(d)	17.4.2 (18.4.2) Reference 1.15 now reads 1.16
(14.5.8(b))		17.4.3 (18.4.3) Reference 10.5.3 now reads 11.5.3
13.5.8(c)	Reference 13.5.7(e) now reads 14.5.7(f)	
(14.5.8(c))		
13.5.8(d)	Reference 13.5.7(a) now reads 14.5.7(a)	
(14.5.8(e))		
13.7.1 (14.7.1)	Reference 13.5.6(b) now reads 14.5.6(b) Reference 13.5.7(c) now reads 14.5.7(c) Reference 13.5.8(d) now reads 14.5.8(d)	
13.9.3 (14.9.3)	Section 10 now reads Section 11	
13.14.1 (14.14.1)	Reference 13.5.3 now reads 14.5.3 Reference 13.14.2 now reads 14.14.2 Reference 13.14.3 now reads 14.14.3	

Cross-references

	<i>Reference 11.3.8 now reads 12.3.8</i>
18.2.1 (19.2.1)	<i>Reference 18.2.2 to 18.2.14 now reads 19.2.2 to 19.2.14</i>
	<i>Reference 18.2.11 now reads 19.2.11</i>
	<i>Reference 18.2.12 now reads 19.2.12</i>
18.2.15 (19.2.15)	<i>Reference 18.2.16 to 18.2.22 now reads 19.2.16 to 19.2.22 (twice)</i>
20.1.2 (21.1.2)	<i>Table 2.20.1 now reads Table 2.21.1</i>
20.1.4 (21.1.4)	<i>Table 2.20.2 now reads Table 2.21.2</i>
20.2.2 (21.2.2)	<i>Table 2.20.2 now reads Table 2.21.2</i>
20.2.3(b) (21.2.3(b))	<i>Reference 1.11.2 now reads 1.12.2</i>
20.2.5 (21.2.5)	<i>Reference 1.7 now reads 1.8</i>
	<i>Reference 20.2.4(c) now reads 21.2.4(c)</i>
20.1.1 (21.1.1)	<i>Reference 20.1.2 to 20.1.4 now reads 21.1.2 to 21.1.4</i>
20.2.1 (21.2.1)	<i>Reference 20.2.2 to 20.2.7 now reads 21.2.2 to 21.2.7</i>
20.3.1 (21.3.1)	<i>Reference 20.2.2 now reads 21.2.2</i>
20.3.3 (21.3.3)	<i>Reference 20.2.2 now reads 21.2.2</i>

Part 7, Chapter 1

1.1.3	<i>Reference Pt 1, Ch 2,2.5.2 now reads Pt 1, Ch 2,2.6.2</i>
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Part 7, Chapter 2

1.3.4	<i>Reference Pt 1, Ch 2,2.5 now reads Pt 1, Ch 2,2.6</i>
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Part 7, Chapter 4

2.3.3	<i>Reference Pt 6, Ch 2,1.5 now reads Pt 6, Ch 2,16</i>
2.3.4	<i>Reference Pt 6, Ch 2,1.5 now reads Pt 6, Ch 2,1.6</i>

Part 7, Chapter 5

5.1.1	<i>Reference 13.1 now reads 14.1</i>
	<i>Reference 13.2 now reads 14.2</i>
	<i>Reference 13.5 now reads 14.5</i>
	<i>Reference 13.7 now reads 14.7</i>
	<i>Reference 13.8 now reads 14.8</i>
	<i>Reference 13.10 now reads 14.10</i>

Part 7, Chapter 6

2.4.2	<i>Reference Pt 6, Ch 2,13 now reads Pt 6, Ch 2,14</i>
5.2.9	<i>Reference 13.10 now reads 14.10</i>
	<i>Reference Pt 6, Ch 2,13.5 now reads Pt 6, Ch 2,14.5</i>

Part 7, Chapter 9

2.3.10	<i>Reference Pt 6, Ch 2,14.5 now reads Pt 6, Ch 2,15.6</i>
3.1.4	<i>Reference 3.10 now reads Pt 5, Ch 7,5.3</i>

4.1.2	<i>Reference Pt 6, Ch 2,14.5 now reads Pt 6, Ch 2,15.6</i>
	<i>Reference 14.5.8 now reads 15.6.8</i>
4.4.1	<i>Reference Pt 6, Ch 2,14.6 now reads Pt 6, Ch 2,15.7</i>
5.3.6	<i>Reference 3.10 now reads Pt 5, Ch 7,5.3</i>
5.5.7	<i>Reference Pt 6, Ch 2,14.5.8 now reads Pt 6, Ch 2,15.6.8</i>

Part 7, Chapter 10

1.1.4	<i>Reference Pt 1, Ch 2,2.5 now reads Pt 1, Ch 2,2.6</i>
4.1.4	<i>Reference Pt 6, Ch 2,12.6 now reads Pt 6, Ch 2,13.6</i>

Part 7, Chapter 12

1.2.2	<i>Reference Pt 6, Ch 2,17 now reads Pt 6, Ch 2,18</i>
2.2.2	<i>Reference 17.3 now reads 18.3</i>
3.1.1	<i>Reference 16 now reads 17</i>
	<i>Reference 17 now reads 18</i>
	<i>Reference 18 now reads 19</i>
3.6.2(g)	<i>Reference 17.4 now reads 18.4</i>
4.1.2	<i>Reference Pt 6, Ch 2,17 now reads Pt 6, Ch 2,18</i>
	<i>Reference Pt 6, Ch 2,18 now reads Pt 6, Ch 2,19</i>
Table 12.3.1	<i>Reference Pt 5, Ch 2,5 now reads Pt 5, Ch 2,7</i>

Part 7, Chapter 14

2.1.4	<i>Reference Pt 6, Ch 2,13 now reads Pt 6, Ch 2,14</i>
4.2.1	<i>Reference Pt 6, Ch 2,1.2.17 now reads Pt 6, Ch 2,1.3.3</i>
4.2.2	<i>Reference Pt 6, Ch 2,1.7 now reads Pt 6, Ch 2,1.8</i>
4.3.3	<i>Reference Pt 6, Ch 2,1.2.4 now reads Pt 6, Ch 2,1.2.6</i>
4.3.4	<i>Reference 1.7.4 now reads 1.8.3</i>
4.3.8	<i>Reference Pt 6, Ch 2,1.7.2 now reads Pt 6, Ch 2,1.8.2</i>
	<i>Reference Pt 6, Ch 2,1.7.4 now reads Pt 6, Ch 2,1.8.4</i>
4.5.1	<i>Reference Pt 6, Ch 2,1.7.2 now reads Pt 6, Ch 2,1.8.2</i>
	<i>Reference Pt 6, Ch 2,1.7.4 now reads Pt 6, Ch 2,1.8.4</i>
Table 14.3.2	<i>Reference Pt 6, Ch 2,10.2.2 now reads Pt 6, Ch 2,11.2.2</i>
6.1.5(j)	<i>Reference Pt 6, Ch 2,1.7 now reads Pt 6, Ch 2,1.8</i>

Part 8, Chapter 2

3.5.2 *Reference Pt 6, Ch 2,15 now reads*
Pt 6, Ch 2,16

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